



Public Interest Energy Research

A N N U A L R E P O R T 2 0 0 2

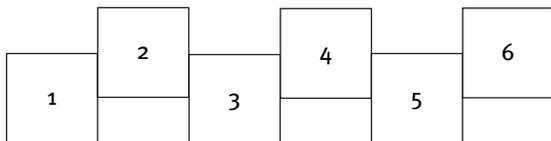


C A L I F O R N I A E N E R G Y C O M M I S S I O N

Appendix A
PIER Program
Project Summaries



Cover Images



1. Residential and Commercial Buildings End-Use Energy Efficiency

Livermore demonstration home equipped with NightBreeze mechanical cooling technology

2. Industrial/Agricultural/Water End-Use Energy Efficiency

Server racks inside a data center from Lawrence Berkeley National Laboratory

3. Renewable Energy Technologies

PowerLight's® flexible photovoltaic/thermal collector, PowerTherm™

4. Environmentally-Preferred Advanced Generation

Catalytica Energy Systems' Xonon® combustion system

5. Energy-Related Environmental Research

Altamont Pass Wind Resource Area (photo by D. Driscoll)

6. Energy Systems Integration

Material Integrity Solutions' sagging line mitigator (SLiM) prototype

Public Interest Energy Research

GRAY DAVIS, GOVERNOR

The Resources Agency of California
MARY D. NICHOLS, Secretary

California Energy Commission
WILLIAM J. KEESE, Chairman
ROBERT PERNELL, Commissioner
ARTHUR H. ROSENFELD, Commissioner
JAMES D. BOYD, Commissioner
JOHN L. GEESMAN, Commissioner

ROBERT L. THERKELSEN, Executive Director



March 2003
P500-02-076A

TABLE OF CONTENTS

RESIDENTIAL AND COMMERCIAL BUILDINGS END-USE ENERGY EFFICIENCY

Projects Funded in 2002 | 2

Projects In Progress | 6

Projects Completed | 30

INDUSTRIAL/AGRICULTURAL/WATER END-USE ENERGY EFFICIENCY

Projects Funded in 2002 | 44

Projects In Progress | 50

Projects Completed | 61

RENEWABLE ENERGY TECHNOLOGIES

Projects Funded in 2002 | 68

Projects In Progress | 81

Projects Completed | 107

ENVIRONMENTALLY-PREFERRED ADVANCED GENERATION

Projects Funded in 2002 | 112

Projects In Progress | 116

Projects Completed | 125

ENERGY-RELATED ENVIRONMENTAL RESEARCH

Projects Funded in 2002 | 128

Projects In Progress | 133

Projects Completed | 142

ENERGY SYSTEMS INTEGRATION

Projects Funded in 2002 | 163

Projects In Progress | 167

Projects Completed | 179

ENERGY INNOVATIONS SMALL GRANT PROGRAM

Projects Funded in 2002 | 199

Projects In Progress | 214

Projects Completed | 229

**Projects Funded through the
Residential and Commercial
Buildings End-Use Energy
Efficiency Program
PIER Program Area**

- Projects Funded in 2002
- Projects In Progress
- Projects Completed



Cool Roof Colored Materials**Contract #:** 500-01-021**Contractor:** Lawrence Berkeley National Laboratory**Contract amount:** \$1,970,000**Match amount:** \$760,000**Contractor Project Manager:** Stephen Weil (510) 486-5396**Commission Contract Manager:** Chris Scruton
(916) 653-0948

Project Description: The purpose of this project is to develop cool colored roofing materials. Until now, a cool roof has been synonymous with a very white roof. In order to address markets where white roofs are aesthetically unacceptable, this project entails development and field testing of roofing materials using colored pigments which are highly reflective in the invisible infrared portion of the spectrum. This technology enables the roof to reject a significant amount of solar radiation while retaining a normal colored appearance. A variety of roofing products will be developed, including composition shingles, concrete and clay tiles, and metal roofing materials. The project includes monitoring short and long-term attributes of the reflective materials in a variety of climatic zones throughout California, in order to assess life cycle benefits as well as susceptibility to degradation.

This project contributes to the PIER program objectives of:

- Improving the environment directly by reducing formation of harmful photochemical smog and indirectly by lowering the need for polluting electrical generation on hot summer days;
- Improving electricity reliability by lowering demand on peak days; and
- Providing greater choices for California consumers by making available attractive roofing products that will lower energy costs, improve indoor comfort and may be longer lasting.

Proposed Outcomes:

- Affordable composition roofing materials which have solar reflectivity increased to 60 percent from the current 10-20 percent, reducing cooling energy and electrical demand by as much as 20 percent in the roughly 4.4 million California single-family detached homes with composition roofs.
- Improvements in the generally superior reflectivity of concrete tiles which dominate new residential construction. This improvement will allow many more concrete tile products to qualify as cool roofs, an appellation that signifies at least 65 percent total reflectivity and 80 percent emissivity.
- More cool roofing product choices and better performance in metal and clay tile products.

Project Status:

The project held an initial PAC meeting on September 12, 2002.

The meeting was well attended by industry, government and research team members. Industry partners, including both major manufacturers of colored roofing granules for composition shingles, are tightly integrated with the research efforts. Prototype products are scheduled for production and testing in 2003 and long-term field monitoring sites are being readied. New product categories and industrial partners continue to join the project.

Advancement of Electrochromatic Windows**Contract #:** 500-01-023**Contractor:** Lawrence Berkeley National Laboratory**Contract amount:** \$639,386**Match amount:** \$2,112,562**Contractor Project Manager:** Stephen Selkowitz
(510) 486-5064**Commission Contract Manager:** Chris Scruton
(916) 653-0948

Project Description: The purpose of this project is to investigate energy and comfort attributes of electrochromic windows, and to develop effective control strategies. These windows can be electrically controlled to vary incoming light transmission by changing from clear to nearly opaque. Electrochromic windows could become widely used in the 21st century if production costs can be lowered and performance is acceptable. The project, which is part of a larger effort by DOE and HUD, includes energy simulations as well as the construction of a test building with several rooms and an instrumented HVAC system for measuring thermal loads. The research products include performance and design information for owners, architects and engineers to lower barriers to early adoption of the technology. The DOE and HUD aspects of the study include long term performance and reliability investigations.

This project contributes to the PIER program objectives of:

- Improving electricity reliability and sufficiency by lowering energy use and peak electrical demands in buildings due to energy gain through windows; and
- Providing greater choice for California consumers by assessing the benefits of an emerging technology, and helping to speed the availability of that technology in the marketplace

Projected outcomes:

- Design guides and energy performance data will become available to early adopters of electrochromic windows, which will help to speed their acceptance and availability as mainstream products.

- Manufacturers and system integrators will benefit from the investigation of control strategies, producing a more satisfactory window-lighting system interaction.

Project Status:

The test facility on the LBNL campus is in the final stages of construction bidding, and the first of the 18x37 windows have been procured from Sage Electrochromics. Potential Policy Advisor Committee members are being contacted.

Modeling for Under Floor Air Distribution (UFAD)

Contract #: 500-01-035

Contractor: Regents – Berkeley

Contract amount: \$610,000

Match amount: \$310,000

Contractor Project Manager: Fred Bauman (510) 642-7848

Commission Contract Manager: Martha Brook P.E.
(916) 654-4086

Project Description: The goal of this project is to develop Under Floor Air Distribution (UFAD) system simulation software that can be used by design practitioners to calculate the energy performance of UFAD systems and to compare the performance of UFAD systems with that of conventional systems. The availability of such a tool will help UFAD technology achieve its full potential by enabling the design of UFAD systems that are energy efficient, intelligently operated, and effective in their performance.

This project contributes to the PIER program goals by:

- Improving the energy cost/value of California's Electricity by fostering the implementation of energy efficient UFAD systems; and
- Improving the environmental and public health costs by insuring that UFAD systems are properly designed to maximize their indoor environmental health and occupant comfort benefits.

Proposed Outcomes:

- Decrease cooling energy and fan energy end-use consumption in commercial buildings by fostering adoption of UFAD technology in 15-40 percent of the building stock.
- Improve the effectiveness of building design and construction practices by providing a validated tool that optimizes the energy and cost effectiveness of UFAD systems and provides the basis for further design tool development.
- Improve the health and safety of building occupants by establishment of a database of test information that could be

used to analyze thermal comfort of UFAD systems and assist with future studies of ventilation effectiveness.

- Increase customer choices for efficient operation of buildings by providing standardized design and analysis tool and technical knowledge that would reduce the risk to practitioners and owners when choosing to implement UFAD technology.
- Encourage the rapid incorporation of research findings into UFAD products by virtue of working closely with UFAD industry leader York International, a partner on this project, and other major HVAC manufacturers who are members of CBE.

Project Status:

This project began in November 2002. The experimental test plans for room air stratification full-scale testing, salt water tank testing, and under floor plenum testing are currently under development. These plans will guide the collection of the empirical data that will inform the model development. The model development phase of this project will begin in the third quarter of 2003.

National Lighting Product Information Program and Daylight

Contract #: 500-02-010

Contractor: Rensselaer Polytechnic Institute

Contract amount: \$450,000

Contractor Project Manager: Russ Leslie (518) 687-7100

Commission Contract Manager: Don Aumann
(916) 654-4588

Project Description: The purpose of this project is to participate in The Lighting Research Center's (LRC) two collaborative research programs in which the California Energy Commission (Commission) will help fund during 2003 through 2004—the National Lighting Product Information Program (NLPIP) and the Daylight Dividend Program (DDP).

The purpose of the ongoing NLPIP program is to continuously research technical issues, perform testing, and provide objective manufacturer-specific information on lighting products and systems. Materials, available in hard copy and on-line, include testing reports and educational information concerning a number of lighting and related technologies including T-5 fluorescent lamps. The purpose of the DDP is to build the market demand for daylight as a means of improving indoor environmental quality, overcome the technological barriers to effectively reap the energy savings of daylight, and to inform and assist state and regional market transformation and resource acquisition program implementation efforts.

This project contributes to the PIER program objective of:

- Improving the energy cost/value to California consumers by offering lower cost to lighting-system owners.

Potential Outcomes:

- Commission funding will expand NLPIP research efforts and direct the results, along with all other NLPIP results, toward lighting decision-makers in California.
- The DDP research will focus on two areas that have been identified as needing significant improvements to ensure that effective daylighting will become common in commercial buildings.
- The first area involves clarifying the benefits of daylight.
- The second area is the need to advance the technological components--photosensors, dimming systems, ballasts--that are required to achieve the greatest energy benefits of daylighting without compromising the comfort and satisfaction of building occupants.

Project Status:

Steering committee meetings for NLPIP and DDP will be held in January 2003. NLPIP resources are available at www.lrc.rpi.edu/nlPIP/index.cfm.

Residential Retrofit Commissioning

Contract #: 500-02-011

Contractor: Bevilacqua-Knight, Inc.

Contract amount: \$414,717

Contractor Project Manager: Robert Knight (510) 444-8707

Commission Contract Manager: Chris Scruton (916) 653-0948

Project Description: The purpose of this project is to merge the best available scientifically validated residential diagnostic and remediation techniques with the existing business practices of building contractors. At present there is no generally accepted set of protocols for testing and repairing systems in houses. Although there are scientifically rigorous methods, these methods may be too cumbersome and expensive for practical use. Conversely, although there are widely practiced rules of thumb, these rules of thumb are wildly inaccurate. This project will use a group of selected contractors to appraise which of the rigorous methods can be used in everyday repair contracting, perhaps in simplified forms. The approved methods will be documented for use as training materials. The net benefits will be validated by before and after energy use monitoring and occupant surveys.

This project contributes to the PIER program objectives of:

- Improving electricity reliability/sufficiency by making existing residences more energy efficient;
- Strengthening the California economy by improving the productivity of California residential contractors; and
- Improving public health and safety by providing more comfortable indoor environments.

Proposed Outcomes:

This project will build on previous PIER residential commissioning research to take the next step of developing it into a practical service. The project will provide California with a small number of practicing residential commissioning contractors, demonstrate the value of this service, and provide the necessary knowledge for replicating it on a larger scale.

Project Status:

The project has been approved for funding by the Energy Commission. Contract processes are underway.

Demonstration of a New, High-Efficiency Air-Conditioning System

Contract #: 500-02-012

Contractor: CoolSmart LLC

Contract amount: \$99,000

Contractor Project Manager: Bill Kopko (202) 588-0100

Commission Contract Manager: Don Aumann (916) 654-4588

Project Description: The purpose of this project is to demonstrate a new air-conditioning system in a Southern California retail facility. The system, designed and patented by CoolSmart, LLC, shows promise for greatly reducing energy use and peak electric demand for cooling commercial buildings. The demonstration should also show if the system satisfies comfort and operating requirements for the building and identify remaining design issues for future work. CoolSmart's system differs from conventional air conditioning in that it separates dehumidification and sensible cooling, allowing for most of the cooling to be done at a higher evaporating temperature. The CoolSmart system uses a ceiling plenum for air distribution at a very low static pressure.

This project contributes to the PIER program objective of:

- Improving the energy cost/value of California's electricity by demonstrating a new, energy-efficient air-conditioning system that is suitable for use in commercial buildings.

Potential Outcome:

- The use of the CoolSmart system is expected to reduce HVAC system energy use by 30 to 60 percent, with total installed cost equal or lower than comparable systems.

Project Status:

The project was approved in late 2002 and will begin in early 2003. Equipment installation should be completed in the summer of 2003.



Energy Efficient Low Income Housing Program**Contract #:** 400-00-036**Contractor:** ADM Associates, Inc.**Contract amount:** \$997,850**Contractor Project Manager:** Taghi Alereza (916) 363-8383**Commission Contract Manager:** Philip Spartz (916) 654-4592

Program Description: The purpose of the Energy Efficient Low-Income Housing Program is to develop information, strategies, and technologies that contribute to reducing energy use and its related expense in low-income households. There are seven energy efficiency projects in the program and they apply to both new and existing housing for low-income households. Two national housing groups, Habitat for Humanity (or HfH www.habitat.org) and Mercy Housing (www.mercyhousing.org) and two manufactured housing builders, Skyline Homes (www.skylinehomes.com) and Fleetwood Homes (www.fleetwoodhomes.com) are participating to help ensure that the program results are used in this housing market.

This program includes 38 test houses and 106 control houses for monitoring results as well. This program is unique because it specifically addresses energy needs of low-income households. Low-income households often incur relatively higher energy costs than higher income groups because of cost barriers commonly associated with energy efficiency measures. This research program, begun in June of 2001 and scheduled to finish in August of 2004, focuses on low-cost options to reduce monthly energy costs and improve the quality of life by improving comfort levels in homes.

This programmatic contract supports the PIER Program objectives of:

- Improving energy cost/value of California's electricity by reducing cooling energy use in new and existing buildings, integrating energy-efficient strategies and products with other building elements, and searching for the highest value strategies and technologies for retrofit;
- Improving the environment, public health and safety by developing ventilation and construction techniques that mitigate moisture and indoor air quality (IAQ) problems; and
- Providing greater choices for California consumers by increasing consumer load management choices

Description of Element 1 – Program Administration:

The administration element coordinates and integrates the technical program elements for the Energy Efficient Low-Income Housing program. Element projects include a kick-off meeting, program meetings, annual technical briefings, monthly progress reports, a final report and a final program meeting.

With several organizations participating in this program, the Program Director must effectively manage the proposed program to achieve the program and project goals within allocated budget and schedule. These tasks require coordinating R&D efforts between the technical program elements, such as overseeing assessment studies, tracking R&D progress and deliverables, ensuring the quality of R&D results, identifying and facilitating program linkages between elements. The Director revisits the program's research direction and focus as research results are achieved, ensures connections with the market and utility deployment programs are made, and establishes systems for reliable internal and external communications throughout the contract period. In addition, the Director coordinates between the other PIER programmatic contracts, by producing and sharing a contact list, web site links, and research bibliographies.

Proposed Outcomes from Element 1:

- Produce all deliverables on time and within budget
- Establish public and team web sites to communicate project results and manage project activities
- Conduct outreach efforts to facilitate adoption in the marketplace

Status of Element 1:

ADM has completed program start-up tasks, signed up subcontractors done several activities related to market connections. They have established a public website for program support and information distribution. Public program documents can be found at www.adm-energy.com/pier.

ADM has also completed the following meetings:

program kickoff meeting	June 7, 2001
first Program Advisory Committee (PAC) meeting	November 20, 2001
second PAC meeting (teleconference)	July 17, 2002
first Critical Program Review (CPR)	March 20, 2002
first Annual Technical Briefing (ATB)	September 26, 2002

The third PAC meeting and second CPR will be held in the first quarter of 2003.

Description of Element 2 – Energy Efficient Low-Income Housing:

The technical element of this work is to improve the energy efficiency of housing often occupied by low-income households. Such housing includes homes built by groups such as Habitat for Humanity (HfH), Mercy Housing (MH) and manufactured housing builders. The relatively higher cost of energy efficient technologies has often precluded them from being installed in

low-income housing (e.g., efficient air conditioning, heat pump water heaters, etc.). However, in houses built by HfH or MH, volunteer workers including the eventual homeowners provide most of the construction labor. This means that implementing more labor-intensive efficiency techniques in the home is a better option for these homes than in houses built for the general population, where high efficiency equipment may be added to the total home cost in the form of an upgrade.

Element 2 includes the following seven projects:

- 2.1) Attic Ventilation
- 2.2) Attic Heat for Water Heating
- 2.3) Ducts In Conditioned Space,
- 2.4) Envelope and IAQ Interactions
- 2.5) Simplified HVAC Controls
- 2.6) Evaporative Coolers and Whole House Fan Integration
- 2.7) Energy Efficiency through Community Design

- The Attic Ventilation project compares the performance of two different methods for decreasing attic heat loads in HfH and manufactured housing to evaluate the relative effectiveness and cost of these methods in reducing space conditioning loads. The objective of the Attic Heat for Water Heating project is to design and evaluate a system for recovering heat from attics in HfH and manufactured houses and use the system for domestic water heating.
- The Ducts in Conditioned Space project goal is to reduce or eliminate energy losses from air conditioning ducts that are usually placed in unconditioned spaces.
- The objective of the Envelope and Indoor Air Quality (IAQ) Interactions project is to evaluate the energy efficiency measures that can be implemented in housing for low-income households without exceeding IAQ standards.
- The Simplified HVAC Controls project objective is to evaluate options for easier-to-use controls, such as occupancy thermostats, for space conditioning systems and understanding how these measures may affect low-income housing energy use.
- The goal of the Evaporative Coolers and Whole House Fan Integration project is to determine if integrating a whole house fan with a standard or an evaporative cooling system provides an economically viable, efficient alternative for comfort cooling needs in new houses for low-income households.
- The Energy Efficiency through Community Design project is determining how best to incorporate narrow streets and shade trees into the designs of low-income single-family housing developments to reduce ambient temperature.

Proposed Outcomes of Element 2:

- Quantified comparison of selected attic ventilation methods

will be used for reducing energy costs related to house conditioning for HfH and manufactured homes. This comparison takes into account implementation costs, which will include all equipment, material and labor costs at market rates.

- A viable attic heat recovery system design for pre-heating domestic hot water, based on a comparison of several systems designed, developed and implemented in low-income houses. Quantitative analysis of each design using field-monitoring data will determine final system recommendation.
- An improvement in duct design in conditioned space for low-income houses or a validation of current methods by implementing and testing different designs of ducts in conditioned space. An optimal duct design will be determined from two rounds of testing with intermediate analysis and system concept refinement.
- Quantitative findings of IAQ improvements resulting from implementing various envelope construction methods and ventilation strategies by measuring carbon dioxide, carbon monoxide, and in some cases mold concentrations in low-income houses.
- Recommendations on improving low-income housing energy efficiency through HVAC controls based on field study of programmable thermostat versus occupancy thermostat usage and the corresponding energy impacts.
- A viable residential design that combines either the whole-house fan plus evaporative cooling/standard air-conditioning or involves whole-house fan alone, and incorporates a simplified, user-friendly control system, based on the quantitative data analysis of temperatures and IAQ plus system effectiveness.
- A strategy incorporating narrow streets and shade trees into low-income housing developments along with algorithms for estimating the potential energy savings, based on data collected from various low-income housing developments in varying degrees of compliance with the suggested design of streets and trees.

Status of Element 2:

Literature reviews have been completed as required for projects 2.1, 2.2, 2.4, 2.5 and 2.6 background methodology for project 2.7 has been delivered. Final site selections have been made for many of the projects, except for project 2.5, when monitoring sites in the southern part of the state will be chosen.

Project 2.1, Attic Ventilation: ADM is monitoring the effect of installing radiant barrier in retrofit house projects by HfH, only required for new construction in CA, and in manufactured housing, governed by federal HUD codes, not CA's Title 24. The project also is monitoring an automatic low-cost, low-

volume roof spray system to reduce attic heat build-up that ADM has designed.

Project 2.2, Attic Heat for Water Heating: ADM created and installed two similar water pre-heating system designs for the attic in several HfH and MH homes. The low-cost systems hold about the same volume as a residential hot water storage tank, are integrated into the home's standard hot water system and include shut-off capability during extreme CA cold periods. Both HfH and MH are excited about using these systems.

Project 2.3, Ducts In Conditioned Space: ADM has selected houses in a MH subdivision where a airtight hallway ceiling dropped plenum will be used to bring the forced-air ducts into the conditioned space. After blower-door and other system tests ensure that forced-air distribution systems are operating well, performance of the dropped-plenum systems will be compared with homes having standard duct systems

Project 2.4, Envelope and IAQ Interactions: The Indoor Air Quality (IAQ) implications of implementing projects 2.3 and 2.6 will be studied. Three homes have been monitored for CO and CO2 levels to date. Data is being submitted for analysis.

Project 2.5, Simplified HVAC Controls: ADM is collecting data on thermostat control use in 48 northern California homes. This data, plus that from another 50 homes in southern California, is being used to develop and refine an occupancy thermostat with simple one-hour heating/cooling override buttons.

Project 2.6, Evaporative Coolers and Whole House Fan Integration: ADM has built an "economizer" box and control system for a manufactured home cooling system. Additionally, they will be integrating the controls for a standard air conditioner and a whole-house fan for a manufactured home. They have developed a control system to cut off the water supply to an evaporative cooler unit when the temperature gets too low. Several of these concepts have been installed and are being monitored.

Project 2.7, Energy Efficiency through Community Design: ADM has collected ambient temperature data during the summer of 2002 from three manufactured home and trailer communities in Sacramento with tree canopy coverage ranging from 10% to 90%. From this data, they are developing a database that will allow them to model these communities for the purpose of designing neighborhoods with reduced space conditioning energy use by lowering the ambient temperature. They will be collecting more data in some similar southern CA communities during the summer of 2003.

Profitability, Quality and Risk Reduction Through Energy Efficiency

Contract #: 400-00-037

Contractor: Building Industry Institute

Contract amount: \$996,020

Match amount: \$1,450,000

Contractor Project Manager: Robert Hammon
(209) 474-8446

Commission Contract Manager: Martha Brook P.E.
(916) 654-4086

Project Description: The purpose of this project is to develop new profit incentives for California homebuilders that will encourage energy-efficient construction. The profit incentives will be generated through reduced warranty costs, increased sales through improved mortgage products, and improved builder and consumer value of energy efficiency through its association with quality and comfort. This contract will also provide builders and their designers with improved analytical tools that will better demonstrate heating, ventilating and air conditioning (HVAC) sizing differences and their associated cost savings, due to quality installations.

This programmatic contract is targeted to the new housing market in California and includes production homebuilders on the program team. These homebuilders will provide information at key times throughout the research and will also review the products for practicality, cost and marketability.

This project supports the PIER Program objectives of:

- Improving energy cost/value of California's electricity by developing efficient technologies and strategies to increase building value and measure benefits; and
- Strengthening the California economy and providing greater consumer choice by working directly with production homebuilders to identify construction practices that simultaneously improve energy efficiency and increase profitability.

Description of Element 1, Program Administration:

This administrative element encompasses overall coordination and integration of the four technical projects of this research program.

Proposed Outcomes from Element 1:

- Research deliverables on time and within budget.
- Public and team websites that communicate project results and manage project activities.
- Presentations, articles and research papers conveying the results of the research, provided to the buildings community

Status of Element 1:

The administrative infrastructure for the research program is in place. The first Program Advisory Committee and Critical Project Review meetings were held earlier this year. The program is behind schedule and the project work needs to be accelerated.

Description of Element 2, Technical Research:

This technical element is composed of the following four large, inter-related research projects:

1. Improved Energy Efficiency, Comfort, and Quality Construction through Reduced Warranty Calls – This project provides a unique opportunity to have builders, a warranty provider, and research organizations work together to make increased energy efficiency in new California homes cost-effective. Production builders' consumer calls will be analyzed to segregate calls into groups, such as structural, HVAC, and moisture. The resulting groups of calls will be correlated with the costs of the warranty calls and possible energy-related improvements in construction techniques and or improvements in energy-related features in the homes. Improved construction practices will be identified and put into a form that is useful to the builder and subcontractors.
2. Value of Quality, Comfort and Energy Efficiency in New Homes – This project will clearly establish the level of consumer interest in energy efficiency, by itself, and when coupled with the additional benefits of quality and comfort. Home Energy Rating Systems will be developed to help consumers compare energy efficiency, quality, and comfort of new homes.
3. Increase Energy Efficiency through Improved Mortgage Products – If significant correlations of home quality, comfort, and energy efficiency problems to home foreclosures are found, the research team will develop a mortgage product that reduces the risk of foreclosures. This project will use the improved home construction practices developed in Project 1, and the home rating system developed in Project 2, to provide a new quality construction mortgage that is relevant to California homes.
4. Improved HVAC Design Mechanisms – This project will develop calculation methods and a design guide for improved HVAC system design.

Element 2 Proposed Outcomes:

- Improved construction protocols will be available for wide distribution. These protocols will not only solve the construction defects but also improve home quality, comfort and energy efficiency.
- A new home rating system will be developed and will be useful for builders as a quality assurance test and for new-home buyers to determine the relative quality, comfort, and energy efficiency of new homes.

- The national Secondary Lender participating in this program is likely to implement the new mortgage guidelines that use the quality, comfort, and energy efficiency rating to reduce risk.
- Improved calculation methods and a design guide for improving Air Conditioning Contractors of America (ACCA) HVAC system design software
- Tools for builders, HVAC designers and subcontractors to optimize HVAC system design, to reduce energy consumption, and save materials and equipment costs.

Element 2 Status:

1. Improved Energy Efficiency, Comfort, and Quality Construction through Reduced Warranty Calls – The research team worked with several builders and a home warranty provider to find data sources for building a database of warranty callback problems. Unfortunately, they discovered that the data that is being captured in the industry today is not rich enough to support the originally envisioned analyses. Instead, the researchers plan to use structured interviews with leading California homebuilders to uncover leading causes of construction defects and callbacks. The problems identified will then be used to develop improved construction practices that save energy while improving builder quality and profitability.
2. Value of Quality, Comfort and Energy Efficiency in New Homes – This project is on hold pending results from the qualitative survey methodology outlined above. The data on common construction problems will inform the development of the quality, comfort, and energy efficiency rating system for new homes.
3. Increase Energy Efficiency through Improved Mortgage Products – Investigation of mortgage foreclosure data showed that the data currently collected is not adequate to establish a statistically significant link between quality, comfort, and energy efficiency problems and home foreclosures. Therefore, this project was cancelled.
4. Improved HVAC Design Mechanisms – A preliminary assessment of calculations widely used for HVAC sizing is largely complete. This will feed into a design guide for software that implements these calculations. Also, a Computational Fluid Dynamics (CFD) model was developed which will be used to establish optimal register and furnace locations for residential HVAC systems.

Synergistic Water Heating and Distribution Technologies Program

Contract #: 400-00-038

Contractor: Davis Energy Group, Inc.

Contract amount: \$767,038

Match amount: \$473,343

Contractor Project Manager: Mark Berman (530) 753-1100

Commission Contract Manager: Philip Spartz (916) 654-4592

Program Description: The purpose of the Synergistic Water Heating and Distribution Technologies (SWHDT) Program is to identify and develop technologies that enable the efficient generation and distribution of hot water, thus providing enhanced comfort and measurable energy savings to California residents. The long-term performance goal is to complete activities that will lead to approximately 600 GWh of annual electricity savings for California ratepayers by the tenth year after program completion.

Four technical projects will be completed:

1. Combined Refrigerator and Electric Water Heater (CREWH) - Development and commercialization of the CREWH, a hybrid appliance that uses waste heat from a refrigerator to heat domestic water.
2. Condensate Recovery System (CRS) - Detailed safety analysis and testing of the CRS, a device designed to reduce the installed cost of residential heat pump water heaters (HPWHs) and increase the locations in houses where they can be installed.
3. Hot Water Distribution Systems (HWDS) - Detailed analysis and evaluation of existing alternate hot water distribution systems in order to identify those that are most efficient for California residential use.
4. Rapid Radiant Distribution System (RRDS) - Development and commercialization of a hydronic radiant slab floor heating system that can be rapidly deployed and utilized by production builders. The goal is to streamline the process and reduce costs of installing such radiant heating systems.

This program began in June 2001 and will be completed in August 2004.

This programmatic contract supports the PIER Program objectives of:

- Improving energy cost/value of California's electricity by reducing cooling energy use in new and existing buildings, integrating energy-efficient strategies and products with other building elements, searching for the highest value strategies and technologies for retrofit, and creating downsized equipment for multi-family applications;
- Improving the environment, public health and safety by developing ventilation and construction techniques that mitigate moisture and IA problems; and
- Providing greater choices for California consumers by increasing consumer load management choices

Element 1 – Program Administration:

Description: This element encompasses overall coordination and integration of the technical program elements for the SWHDT program. The projects comprising this element include a kick-off meeting, program meetings, annual technical briefings, monthly progress reports, a final report, and a final meeting.

Proposed Outcomes from Element 1 are to:

- Produce all deliverables on time and within budget
- Establish a web site to communicate project results and manage activities
- Conduct outreach efforts to facilitate commercialization of results

Status of Element 1:

In addition to program start-up administrative tasks (establish subcontracts, issue bills, produce reports), Davis Energy Group (DEG) has completed several market connection activities. The website has areas for program support and information distribution - public documents are available at www.davisenergy.com/swhdt/.

DEG has completed the following meetings:

program kickoff meeting	June 26, 2001
first Year-End Report	June 01, 2002
first Critical Program Review (CPR)	July 24, 2002
first Annual Technical Briefing (ATB)	August 22, 2002

They have also has submitted monthly progress reports and held quarterly teleconference calls for selected members of the program advisory committee (PAC) to discuss the progress of all four projects.

Element 2 –Efficient Hot Water Generation:

Description: The technical element of this work is to identify and develop technologies that enable the efficient generation of hot water. This element has two projects:

1. Project 2.1, Prototype Development of a Combined Refrigerator and Electric Water Heater (CREWH). This project will develop a cost-effective combined refrigerator and electric water heater that can significantly reduce overall energy consumption in California homes by fully or partially heating domestic water with refrigerator discharge heat, simultaneously delivering "free" cooling to the kitchen. After conducting feasibility studies, two different CREWH prototypes will be built, tested and evaluated.
2. Project 2.2, Safety Analysis & Testing of Heat Pump Water Heater Condensate Recovery System (CRS). This project will obtain laboratory evidence supporting the safety of injecting sterilized condensate from a residential heat-pump water

heater into the water storage tank. Project tasks include conducting a preliminary hazard analysis, designing a test apparatus, and fabricating and testing the prototype technology.

The proposed outcomes of Element 2 are as follows:

- An understanding of the economic feasibility of applying CREWH technology to particular California residential applications
- New baseline product information about commercializing the CREWH technology by constructing two full-scale prototype units
- Expected energy savings from implementing the optimal CREWH configuration
- Structured laboratory investigation of the health risks associated with injecting heated condensate from a heat pump water heater back into the storage tank

Status of Element 2:

Project 2.1: The initial designs considered for CREWH modeling were:

- 1a - A combined refrigerator and heat pump water heater designed to supply substantially all of the hot water needs of a household
- 2a - CREWH with an external hot water storage tank, for heating water only when the refrigerator compressor operates to cool stored food
- 2b - Same as 2a, except the hot water storage tank is integral to the CREWH, eliminating the need for a separate circulation pump.

After a multi-program software analysis of these models and consultation with Maytag and a segment of the PAC, it was decided to proceed with design 2b. The resulting CREWH unit will thus be designed primarily to heat water for use in the kitchen. The first prototype CREWH unit for this program is being assembled and unit testing should begin during the first quarter of 2003.

Project 2.2: A preliminary hazard analysis, a laboratory test plan, a fabrication report and a laboratory test report were completed and submitted. A version of the final report has been written and been briefly reviewed by Commission staff and staff at the California Department of Health Services Division of Drinking Water and Environmental Management. The analysis of the CRS technology -- carried out by contractor Arthur D. Little, Inc. -- indicated any safety issues for residential use should be negligible.

Element 3 –Efficient Hot Water Distribution:

Description: The technical element of this work is to identify

and develop technologies that increase the efficiency of hot water distribution. The element has two projects:

1. Project 3.1, Evaluation of Alternate Hot Water Distribution Systems (HWDS): The HWDS project evaluates performance and economic benefits of existing domestic hot water distribution systems that can improve energy efficiency of hot water delivery in California residences. Potential energy savings, a cost-benefit analysis, and market barriers for alternative new systems will be performed.
2. Project 3.2, Development and Demonstration of a Rapid Radiant Distribution System: The RRDS research will develop system concepts for installing radiant hydronic floor systems faster. Preferred concepts will be chosen, product requirements defined and prototype RRDS arrays installed. A production readiness plan will also be prepared.

The proposed outcomes of Element 3 are as follows:

- An understanding of alternative domestic hot water distribution systems that will increase energy efficiency in California residences, and
- A demonstration to the building industry that radiant hydronic distribution systems can be installed three to four times more quickly than current practice.

Status of Element 3:

- Project 3.1: Subcontractor ORNL used material properties, component geometry, insulation and other relevant system parameters to construct a computer model for simulating three types of plumbing systems (conventional, recirculation and parallel-pipe manifold). Simulations based on seven representative plans for both new and existing California houses have been run in the resulting LabVIEW program. Some algorithm development work is ongoing, based on PAC review of the simulation results. Various plumbing, system material, and labor costs, plus utility rate information gathered from 10 California cities are being used for economic comparison of the systems. California plumbing contractors have also been surveyed to understand possible motivations for installing more efficient systems.
- Project 3.2: A survey of industry professionals was used to list and discuss the perceived market barriers for installation of hydronic radiant slab floor heating systems by production builders. An installation of a radiant slab heating system was observed at a custom homesite to better understand current procedures used. As part of a basic system concept that was developed in response to initial investigations, manufacturing partner IPEX produced a prototype run of pre-configured radiant tubing that can decrease radiant system layout time. CAD models of several different design concepts for more rapid installation of radiant systems were developed and refined after consultation with PAC members, a preferred

prototype configuration was then chosen. The modular concept includes offsite attachment of radiant tubing using special jigs, an automatic tying tool, and spacers that correctly position welded wire mesh within the concrete slab. The prototype will use a floor-mounted modular enclosed manifold. An installation site has been chosen for installation of the prototype RRDS concept during the first quarter of 2003.

Commercial Buildings Cool Roofs Monitoring

Contract #: 400-00-039

Contractor: Lawrence Berkeley National Laboratory

Contract amount: \$305,000

Contractor Project Manager: Hashem Akbari (510) 486-4287

Commission Contract Manager: Philip Spartz (916) 654-4592

Project Description: The purpose of this project is to determine the savings associated with commercial cool roof systems by monitoring the actual performance of a carefully selected assortment of buildings participating in the Commission's AB970 Peak Load Reduction, Cool Communities (Cool Roof Retrofit) Program. The selected buildings must be scheduled for re-roofing and meet the criteria for project data collection purposes. Monitoring buildings is necessary to produce data that will help researchers better understand the peak savings resulting from the application of a cool roof.

This project supports the PIER Program objectives of:

- Improving energy cost/value of California's electricity by reducing peak demand, thereby reducing the associated higher costs of supplying/purchasing energy during constrained periods; and
- Improving the reliability/quality/sufficiency of California's electrical system by reducing peak demand.

Proposed Outcomes:

- Increased knowledge of the peak and energy savings achievable with cool roof applications
- Improved building energy simulation capabilities in the area of roof heat transfer

Project Status:

After interviewing over 100 potential participants, seven commercial buildings have been recruited for monitoring, based on the following primary selection criteria:

- a single-story building
- roof area between 9,000-200,000 ft²
- no roof insulation to be added during re-roof
- air conditioning used between June–September

The selected buildings are:

- a Sacramento retail building
- a San Diego school building
- a Reedley fruit-packing complex (near Fresno industrial, warehouse, and cold-storage buildings, equivalent to four structures)
- an Irvine office

Pre-retrofit monitoring for base-case comparison of all seven buildings has been completed. The Sacramento, San Diego and Fresno-area buildings have been retrofitted with cool roofs, and post-retrofit data has been collected at these three locations.

The Irvine office did not re-roof.

Analyses of the results to date reveal that the Sacramento retail building showed over 50 percent savings in energy after installing the cool roof. Results are not as obvious from the school and fruit-packing complex data. Some additional monitoring would be necessary to clarify the situation at these sites.

Energy Efficient and Affordable Small Commercial and Residential Buildings for a Growing California

Contract #: 400-99-011

Contractor: Architectural Energy Corporation

Subcontractors: Battelle-Pacific Northwest Division, The National Institute of Standards and Technology (NIST), Purdue University, Massachusetts Institute of Technology (MIT), Oak Ridge National Laboratory (ORNL), Schiller Associates, Heat-Timer Corporation, Newport Design Consultants

Contract amount: \$5,422,000

Match amount: \$5,787,000

Contractor Project Manager: Donald Frey (303) 444-4149

Commission Contract Manager: Chris Scruton (916) 653-0948

Program Description: The purpose of the Energy Efficient and Affordable Small Commercial and Residential Buildings Program is to develop and demonstrate technologies to improve energy efficiency. The program addresses such issues as peak electrical demand, healthful indoor environments, and California building affordability. It also strengthens the energy efficiency industry in California by providing new jobs and growth opportunities for companies that provide technology, systems, software, design, and building services. High impacts and direct benefits for every research dollar are provided by projects that are synergetic, market-oriented, and supported by industry. The Program consists of 6 elements, each element having one or more projects.

This program supports the PIER Program objectives of:

- Improving California's economy by allowing energy-saving measures to be integrated into the early design of a building, thereby making energy-efficient measures more cost effective;
- Improving the reliability and quality of California's electricity by reducing peak demand, leading to lower infrastructure costs and better reliability; and
- Improving California's natural environment by reducing the demand for electricity, with consequent air and water pollution reductions

Element 1: Program Management

Description: This element provides program administration for all technical elements and overall coordination and integration of all the subcontractors and work tasks. The prime contractor manages the technical work in addition to handling all administrative activities. This element also includes outreach efforts to establish market connections between the research teams and industry.

Proposed Outcomes:

- Manage industry and public advisory groups to maximize practical input
- Establish public and team web sites to communicate project results and manage project activities
- Conduct outreach efforts to facilitate adoption in the marketplace

Element Status:

- The web site is operational and periodically updated. The web site includes informational public areas as well as password protected areas for management use.
- A Public Advisory Committee of involved professionals has been formed and has had 7 meetings, providing input and guidance as needed.
- Biweekly conference calls with key members of the technical teams are held to assess and maintain project progress and solve problems.
- Regular monthly reports, critical project reviews, and two annual reports have been generated.

Element 2: Automated Commissioning and Diagnostics

Description: This program element's work scope involves the following technical projects:

- Fault Detection and Diagnostics for Rooftop Air Conditioning diagnoses problems automatically using sophisticated algorithms to compare reference performance with actual performance. Ultimately the software is expected to be incorporated into unit controllers.
- Equipment Scheduling and Cycling uses a Non-Intrusive Load

Monitor (NILM) located at a power service entrance or motor control center to automatically identify which equipment is operating at a given time and how much energy it is consuming. It can be used to identify malfunctioning equipment.

- Air Handling Unit and VAV Box Diagnostics uses rule based and statistical analysis techniques to automatically detect problems in these devices. The diagnostic algorithms are embedded in the unit controllers to reduce communication requirements.
- Demonstration of the Whole Building Diagnostician (WBD) involves field testing this software tool, which is currently able to diagnose problems in air handlers.
- Pattern Recognition Based Fault Detection and Diagnostics is an extension of the ENFORMA diagnostic tool, enabling it to automatically draw conclusions about the performance of boilers, chiller plants, and cooling towers.
- Enhancement of the Whole Building Diagnostician (WBD) extends the energy analysis capabilities of this diagnostic tool, allowing peer comparisons between different buildings and normalizing performance based on user defined independent variables.
- Enabling Tools for testing the Whole Building Diagnostician (WBD) on the Virtual Cybernetic Building Testbed, allows the WBD to process information from a simulated building mechanical system, including various simulated equipment faults, to test the WBD's ability to detect those faults.

Proposed Outcomes:

- Development and demonstration of FDD will lead to commercialization and deployment and ultimately energy and comfort benefits in buildings with unitary equipment.
- NILM development and deployment will lead to improved equipment operation, fault detection, and equipment energy use.
- VAV and AHU diagnostics integrated with building control systems will lead to load reductions and better comfort in buildings where deployed.
- WBD deployment will allow automatic diagnosis of the nearly ubiquitous outside air economizer problems. The WBE enhancement will allow flexibility in relating energy consumption to variables other than temperature.
- Pattern recognition based software will facilitate operator response in repairing central plant equipment.
- The enabling tools will be valuable to developers of diagnostic tools for product testing.

Element Status:

- FDD, VAV and AHU diagnostics, pattern recognition based fault detection, and the NILM are all under active development and operational testing.

- The WBD and WBE are undergoing field testing at 3 sites in California.

Element 3: Advanced Load Management and Controls

Description: This program element's work scope involves the following technical projects:

- Demand-Controlled Ventilation (DCV) Assessment analyzes the potential of CO₂ sensors to replace fixed ventilation requirements in order to improve indoor air quality and save energy. It also identifies specific applications in which DCV will have best potential.
- Night Ventilation with Building Thermal Mass investigates the use of cool night air to cool the mass of a building, which lowers the demand for cooling during hot daytime hours and can reduce peak loads. It is also investigating applications of mechanical pre-cooling strategies.
- Smart Load Control and Grid-Friendly Appliances are devices which can detect conditions of electrical system stress and automatically turn off appliances in response. This project is investigating the feasibility of local grid stress detection.
- Extending BACnet for Lighting and Interfacing Building Systems with Utilities is developing the ability of BACnet facility management systems to control lighting loads and to respond to price or load shedding signals from utilities.
- Aggregated Load Shedding using Non-Intrusive Load Monitor (NILM) investigates the ways buildings can reduce electrical demand while still maintaining comfort conditions.

Proposed Outcomes:

- Use of Demand Control Ventilation and Nighttime Cooling will reduce energy use, demand, and potentially improve indoor air quality in buildings
- Extensions of BACnet will facilitate intelligent control of more of a buildings functions leading to better demand responsiveness and grid reliability.

Element Status:

- Extensive literature research and simulations on applications of DCV have been carried out, with reports published. Calibration of the simulations of both DCV and Nighttime Cooling with field testing is ongoing.
- Investigations into the ability to detect grid stress conditions using frequency and voltage indicators at the consumer level are ongoing.
- Lighting and Utility Industry coordination and software standards are being developed by the BACnet standards group.
- Field testing of load shedding and energy reduction strategies is underway in Los Angeles County and Alameda County buildings using the NILM to measure electrical use.

Element 4: Alternative Cooling Technology and Strategy

Description: This program element's work scope involves the following technical projects:

- Assessment and Field-Testing of Ventilation Recovery Heat Pumps.
- Residential Hydronic Radiant Heating and Cooling System Demonstration.
- Design Methods and Guidelines for Natural Ventilation in California

Proposed Outcomes:

- The residential radiant hydronic heating and cooling system investigation will demonstrate the potential benefits this building method provides for demand and energy reduction, leading to more widespread acceptance of this type of comfort control system.
- Software tools for modeling of naturally ventilated buildings will lead to more widespread development and use of low energy natural and hybrid ventilation systems.

Element Status:

- Field-testing and calibration of simulation models for ventilation recovery heat pumps is underway in California schools.
- Comparison of energy use and comfort characteristics of a house using various combinations of forced air and hydronic radiant slab heating and cooling is ongoing.
- A report on prior work along with a suitability analysis for California climates is complete. The natural ventilation software design tool has been submitted for expert review.

Element 5: Energy Efficient Construction Technology

Description: This program element's work scope involves the following technical task:

- Building-Integrated Photovoltaics investigates the effects on PV performance when they are integrated with building envelope components. Some of the potential factors are orientation, shading and temperature effects.

Proposed Outcomes:

This project will quantify the performance expectations for photovoltaic cells when integrated into residential and commercial building construction, leading to more accurate design information.

Element Status:

The photovoltaics are installed and the performance is being monitored and analyzed. The project uncovered significant inaccuracies in widely used simulation software.

Element 6: Impact Assessment of Project Results

Description: This program element involves the development of a standard methodology for predicting energy impacts of technology development and adoption.

Proposed Outcomes:

By assessing the potential impacts of projects or developments on energy use in California this project will help to guide where scarce research funds can provide the maximum benefit.

Element Status:

The methodology is currently under active development.

High Performance Commercial Buildings Systems

Contract #: 400-99-012

Contractor: Lawrence Berkeley National Laboratory
Subcontractors: Texas A&M University (TAMU), Massachusetts Institute of Technology (MIT), University of California-San Diego (UCSD), University of California- Berkeley (UCB), Davis Energy Group (DEG)

Contract amount: \$5,995,385

Match amount: \$3,093,049

Contractor Project Manager: Richard Wilson (510) 486-7391

Commission Contract Manager: Martha Brook P.E. (916) 654-4086

Project Description: The purpose of the High Performance Commercial Building Systems Program is to develop and deploy a set of energy savings technologies, strategies, and techniques to help improve processes for designing, commissioning, and operating commercial buildings. The goal of this program is to reduce energy use in the California commercial sector by 22 percent by 2015. At the same time this program will strengthen the growing energy efficiency industry in California by providing new jobs and growth opportunities for companies providing the technology, systems, software, design, and building services to the commercial sector.

This program contains one administrative element and five linked technical program elements that collectively contain 14 projects with 41 distinct R&D tasks. Collectively they create a comprehensive Research, Development, and Demonstration (RD&D) program with the potential to capture large savings in the commercial building sector, providing significant economic benefits to building owners and health and performance benefits to occupants.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by helping customers optimize their building systems to

perform at peak efficiency; and

- Improving the reliability/quality of California's electricity by helping lower peak electrical demand from California's commercial building sector.

A public website (<http://buildings.lbl.gov/cec/>) has been established for this research program.

Element 1, Program Administration:

Description: This administrative element encompasses overall coordination and integration of the five technical program elements for the High Performance Commercial Building Systems program. With five subcontractors, fourteen match contributors and staff from as many organizations participating in this program, only effective management will achieve the program and project goals within allocated budget and schedule.

Proposed Outcomes from Element 1:

- Research deliverables on time and within budget.
- Public and team websites that communicate project results and manage project activities.
- Presentations, articles and papers conveying the results of the research, provided to the buildings community

Status of Element 1:

Significant technical progress was made in each of the five program elements in Year 2. A total of 55 milestones and deliverables have now been completed. The level of activity to develop market pathways increased in Year 2, and will be a strong focus for the remaining program term.

Element 2, Life Cycle Tools:

Description: The purpose of this element is to develop integrated information management technologies to assist in improving commercial building performance. This element is divided into three projects: Performance Metrics and Benchmarking, Retrofit Tools, and Interoperability. The three specific problems addressed in this element are related to:

- Lack of standard performance metrics and benchmarking tools and techniques
- Lack of standard methods for retrofit performance analysis
- Lack of standard methods for exchanging data among software programs

Proposed Outcomes of Element 2:

- An operational web-based benchmarking tool for commercial buildings. This tool will allow facility managers and building owners to judge their building's energy performance, compared to industry norms.
- A building energy performance metrics tracking tool for

commercial buildings. This tool will allow building operators and commissioning agents to archive, track and visualize key features of HVAC equipment operation.

- High-speed metering proves to be an effective approach to evaluate commercial building energy performance. High-speed meter technology is commercialized in national energy communications markets.
- A performance measurement tool for retrofit applications that will predict energy savings for potential energy efficiency measures. The tool will enable building operators and ESCOS to make informed retrofit recommendations to building owners.
- Interoperable data schema for HVAC systems that will facilitate the exchange of HVAC system information between energy analysis tools and other building design tools. The interoperability of these building design tools will encourage architects and mechanical engineers to study the energy impacts of alternatives early in the building design process.

Status of Element 2:

The work in this technical element had resulted in the following products:

- Web-based benchmarking tool for California commercial building energy use
- Prototype software for building performance metrics tracking
- Alpha-version of an energy retrofit identification tool
- Alternative methods to provide useful metrics to building owners/operators that will encourage comparison of their energy use with that of others
- Industry Foundation Classes (IFC) object data models that support the modeling and simulation of HVAC components and systems

In the final year, these products will be further refined, and tech transfer activities will be a principal focus.

Element 3, Lighting, Envelope and Daylighting:

Description: The purpose of this element is to develop an integrated building equipment communications (IBECS) network that will allow appropriate automation of lighting and envelope systems to increase energy efficiency, improve building performance, and enhance occupant experience in the space. This network will provide a low-cost means for occupants to control local lighting and window systems, thereby improving occupant comfort, satisfaction and performance. A related goal of this program element is to improve existing lighting control components and accelerate development of new daylighting technologies that will allow daylighting to be more extensively applied to a larger proportion of building floor space. This element consists of three research projects: Lighting Controls, Daylighting, and

Lighting Network Operations.

Proposed Outcomes from Element 3:

- A building equipment communications network (IBECS) that allows automation of lighting and envelope systems. The IBECS will include interfaces with controllable ballasts, wall switches, occupant sensors, electrochromic windows, venetian blinds, and BACnet-compliant building energy management systems.
- Software that will operate on the IBECS network to support commissioning of building lighting systems.
- Software that will operate on the IBECS network to support lighting and envelope system diagnostics.

Status of Element 3:

The technical work in Element 3 continued to develop, test and demonstrate monitoring and control components for IBECS. A multi-purpose environmental sensor was developed that is capable of measuring key variables such as occupancy, light level and temperature, and transmitting this information through a network interface to IBECS. In this second year of work it was decided to focus the remaining project activities into a full-scale IBECS demonstration. The reliability of the IBECS communications network will be tested in a realistic, uncontrolled office environment. The individual functionality as well as the integration of each of the IBECS components developed to date will also be demonstrated in this full-scale pilot implementation.

Element 4, Low Energy Cooling:

Description: The purpose of this element is to identify and evaluate appropriate combinations of low-energy cooling technologies, including more efficient distribution systems, and to develop the simulation models required both for this evaluation and for the design of such systems for individual buildings. This research element is separated into three projects: Appraisal of System Configurations, Efficient Distribution Systems, and Tools and Guides.

Proposed Outcomes from Element 4:

- Increased industry knowledge of the energy and peak demand savings potential of low energy cooling technologies in commercial buildings for distinct California climate regions.
- Building energy simulation software effectively models both individual and combinations of low energy cooling technologies.
- The benefits of efficient duct systems are accounted for in the Title-24 compliance procedures for non-residential buildings.

Status of Element 4:

For the Appraisals of System Configurations project, the energy savings and peak demand reductions associated with the use of direct and indirect evaporative cooling, displacement ventilation and cool beams have been estimated for various California climates, occupancy patterns and ventilation requirements. In the final year, improved models developed in the Tools and Guides project will be used to refine estimates of the most promising systems for California, and occupant comfort will also be assessed.

The Efficient Distribution Systems project has been inactive thus far, pending the conclusion of a preceding project (PIER Contract #500-98-035), which is now complete. In the coming year this project will review duct system modeling approaches and recommend an approach to conduct benefits analyses in support of the 2008 Building Energy Efficiency Standards. This project will also develop an approach to include an overall metric for distribution system efficiency into the reporting requirements for future building standards.

The modeling efforts within the Tools and Guides project have resulted in models of heat transfer and air temperature distribution in spaces with displacement ventilation, buoyancy-driven and cross-flow ventilation. The displacement ventilation model has been incorporated successfully into a research version of EnergyPlus. In the final year the model integration with EnergyPlus will continue for the various air flow regimes and a Flow Selection Module will be developed to determine the appropriate air flow model to use within a building energy simulation.

Element 5, Integrated Commissioning and Diagnostics:

Description: The objective of this element is to assemble and develop a set of manual tools, test procedures and guides to support the commissioning of HVAC, lighting and other building systems. This work will result in diagnostic procedures and commissioning tools needed by owners, operators and the commissioning industry to perform and analyze test results and operate buildings efficiently. This element's work scope is organized into three large research projects: Commissioning and Monitoring for New Construction, Monitoring and Commissioning for Existing Buildings, and Advanced Commissioning and Monitoring Techniques.

Proposed Outcomes from Element 5:

- A library of HVAC functional test procedures for medium and large commercial building systems is widely used, resulting in improved energy performance in California buildings.
- A commissioning and monitoring design guide proves to be an effective reference for the development of building system specifications, allowing design intent to be realized in

building construction projects.

- Fault detection and diagnosis is improved by data monitoring and visualization systems and building simulation techniques, which allows building operators, engineers and energy service personnel to make equipment operation decisions that save energy and increase equipment lifetimes.
- Methods to employ existing EMCS for monitoring and diagnostics are developed, facilitating large energy saving opportunities in medium and large commercial buildings.
- High-speed electric meters prove to be effective at diagnosing equipment faults and are marketed both as stand-alone meters and as integral components of EMCS.
- Occupant feedback systems are refined and integrated with building system controls to make decisions and take actions that improve occupant comfort.

Status of Element 5:

The second year of this large and diverse technical element has been very productive, yielding the following research products:

- Functional Test Guide for Air Handling Systems, which includes field-proven educational material necessary to troubleshoot common problems, as well as control system design guidance
- Built-Up Fan System Diagnostic Tools
- Data Logging Guides for Energy Management Control Systems (EMCS)
- Prototype for an automated technology that will categorize and quantify the state of installed energy measurement sensors in an existing EMCS, for use in building monitoring and diagnostics
- Improved Non-Intrusive Load Monitors
- Information technology for occupants to exchange building operations information with building automation systems, providing occupants with real-time system information and aiding maintenance personnel in diagnosing problems reported by occupants
- Library of equipment models suitable for use in component-level functional testing and performance monitoring

Element 6, Indoor Environmental Quality:

Description: The purpose of this element is to demonstrate and stimulate the use of HVAC technologies and indoor pollutant source control technologies that save energy and simultaneously improve IEQ, providing a foundation for improvements in the health and learning of students. This element is composed of two related research projects: Energy Simulations and Projected State-Wide Energy Savings, and Energy & IAQ Field Studies.

The research objectives of this element are to:

- Measure and evaluate energy savings, costs, and

improvements in thermal comfort, indoor air quality, and noise achieved with advanced HVAC system and building interior finish material selection.

- Develop new, timely information on indoor environmental conditions in California Relocatable Classrooms (RCs).
- Evaluate the accuracy of models to predict energy consumption in RCs and upgrade computer modeling tools, and thus estimate the potential energy savings from widespread use of the energy-efficient HVAC technologies in RC and similar modular buildings.

Proposed Outcomes from Element 6:

- Field tests of advanced HVAC technologies suitable for RCs demonstrate energy performance and IEQ improvements.
- Field test results improve computer models, which are then used to estimate the energy savings potential for advanced HVAC technologies in RCs and other building types for a range of California climate regions. This information provides a sound basis for school districts and their consultants to save energy and improve the IEQ of California schools.
- Volatile Organic Compound (VOC) source control measures in RCs are evaluated and the results are shared widely with RC manufacturers, promoting healthier learning and teaching environments in California schools.

Status of Element 6:

The second year's work within the Energy Simulations and Projected State-Wide Energy Savings Project produced estimates of the energy savings potential for high performance relocatable classrooms in California. These estimations are currently being refined using the energy use data collected during 2001 and 2002 at two demonstration school sites. In the final year the potential for energy savings and cost benefits of low energy cooling systems in California schools will be published, then presented publicly to stakeholders.

For the Energy & IAQ Field Studies project, the field studies are now complete. Working with one relocatable classroom manufacturer, four high performance classrooms were constructed and sited, two each, at two school districts in extreme and moderate California climates. A low energy cooling system was installed and monitored in each classroom. Energy use and indoor air quality measurements were taken in all four classrooms for one cooling season and one heating season. In the final year a brochure and website on the subject of classroom ventilation and construction material selection will be created for information dissemination.

Integrated Energy Systems-Productivity and Building Science

Contract #: 400-99-013

Contractor: New Buildings Institute, Inc.

Subcontractors: Heschong Mahone Group, Eley Associates, Inc., Architectural Energy Corporation, GARD Analytics, Inc., RLW Analytics, Inc.

Contract amount: \$5,876,972

Contractor Project Manager: Cathy Higgins (509) 493-4468

Commission Contract Manager: Don Aumann
(916) 654-4588

Project Description: The purpose of the Integrated Energy Systems Productivity and Building Science Program is to promote develop energy-efficient systems solutions through integrated systems research. The project has one administrative element and six technical elements. Each technical element is designed to fill major gaps in the existing body of building science knowledge. It is not the individual component, but how they are assembled into and operated within a building system, that determines energy efficiency. The term of this project is August 2000 to August 2003.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by allowing energy-saving measures to be integrated into the early design of a building, thereby making energy-efficient measures more cost effective;
- Improving the reliability/quality of California's electricity by reducing peak demand and improving load factor, leading to reduced infrastructure costs and system reliability risks; and
- Improving the state's economy by developing energy-efficient solutions that also increase worker/student productivity or increase retail sales

Element 1, Administration, Management and Market Connections:

Description: The purpose of this element is to provide program administration for all technical elements and provide overall coordination and integration of all the subcontractors and work tasks. The prime contractor manages the technical work in addition to handling all administrative activities (e.g., contracts, billing, reporting, tracking, etc.) to ensure that all tasks are completed within allocated budget and schedule. This element also includes outreach efforts to establish market connections between the teams completing the research and the users of the research results.

Proposed Outcomes from Element 1:

- Deliverables on time and within budget
- Public and team web sites to communicate project results

and manage project activities

- Outreach efforts that facilitate adoption in the marketplace

Status of Element 1:

In addition to completing extensive administrative tasks (manage subcontracts, issue bills, and produce reports) NBI completed numerous activities related to market connections. Additionally, NBI developed, and began implementing, a market connections plan to strengthen the market impacts by the end of the contract in 2003. Most of the detailed findings and documents completed thus far can be found on the contractor's website (www.newbuildings.org/pier).

Element 2, Productivity and Interior Environments:

Description: The purpose of this element is to establish actual measurements of the productivity and energy values of daylighting, natural ventilation and high quality lighting in the operation of commercial buildings. The project also seeks to establish and refine a field methodology that can successfully make a compelling association between human performance criteria and building characteristics. Validation and quantification of the productivity value of energy efficiency measures will likely motivate decision-makers to include these measures in buildings. The researchers are investigating these issues in the following facility types: schools, retail outlets, and offices.

Proposed Outcomes of Element 2:

- Data correlating reduced building energy costs with improved student performance, increased retail sales, and improved office and manufacturing worker productivity
- Reduced whole building energy use due to increased use of daylighting by motivating decision-makers to demand daylighting in their buildings
- A field methodology that can successfully link human performance to building characteristics

Status of Element 2:

- Task 2.2, Reanalysis of Daylighting in Schools study: The final report was completed in early 2002 and has been downloaded over 2400 times. The lowest possible estimate for the impact of daylight on student learning is a 7 percent increase in learning rates between those classrooms with the least to the most daylight. The highest estimate is 37 percent. Daylighting conditions, operable windows and air conditioning were not significant in predicting student absences.
- Task 2.3, Daylighting and Retail Sales: The team completed their analysis at the year end and is preparing for peer review.
- Task 2.4, Daylighting in Schools: Analysis is nearly complete.

- Task 2.5, Daylighting in Manufacturing: Project was cancelled because no suitable project partner was available. The funding was put into Task 2.6, Daylighting in Offices, adding a second test site.
- Task 2.6, Daylighting in Offices: The two sites include a standard office and a call center. Data collection was completed in December 2002.

The research team presented project results at three conferences.

Element 3, Integrated Design of Large Commercial HVAC Systems:

Description: The purpose of this element is to develop design guidelines for large commercial HVAC systems, focusing on variable-air-volume systems with chilled water plants. While covering only a minority of all systems installed in California, this is the most common type of large HVAC system and accounts for an estimated 20 to 25 percent of the state's cooling capacity.

This element consists of the following five research projects within the central theme of integrated design of large commercial HVAC systems:

1. Field studies
2. Building science solutions
3. Statewide energy impacts
4. Findings and draft recommendations
5. Guidelines for integrated HVAC system design

Proposed Outcomes from Element 3:

- A set of design guidelines to promote the use of advanced, integrated design strategies in new construction and retrofit projects
- 25 percent HVAC savings in the target building population, with the total demand savings of about 4.1 MW and energy savings of about 4100 MWh/yr.

Status of Element 3:

Work completed thus far includes:

- identifying the population of buildings in California larger than 100,000-sqft and built since 1995
- 500 interviews with building representatives to screen sites for monitoring
- 20 site inspections of the best monitoring candidates
- selecting 5 sites for monitoring
- developing monitoring plans
- installing data monitoring equipment at all five sites
- collecting most of the data for evaluating building improvements
- developing a prototype design guideline

- presenting preliminary research results at the ACEEE conference

Element 4, Integrated Design of Small Commercial HVAC Systems:

Description: The purpose of this element is to develop general guidelines for specifying and installing high-performance systems, document statewide savings potentials, and identify future code upgrade options. The project scope includes packaged heating, ventilation and air conditioning (HVAC) systems up to 10 tons per unit—the most common HVAC systems for small commercial buildings in California. Through short-term monitoring and onsite surveys of current practice, the team will identify problems with equipment, controls, distribution systems, and operation and maintenance practices that lead to poor system performance.

Proposed Outcomes from Element 4:

- An understanding of common practices with equipment and controls (economizers, fan/thermostat, scheduling, etc.), distribution systems, and operation/maintenance practices that lead to poor system performance
- Increased energy efficiency and functionality of small commercial HVAC systems by 10 percent through both technical improvements to building design practices and widespread adoption of the improvements identified in the project
- Future code upgrade options

Status of Element 4:

The research team completed data collection at 75 sites totaling 225 individual HVAC units. Key findings include:

- Economizers frequently do not function properly
- Thermostats are not typically capable and/or set to provide fresh air required according to Title-24 while simultaneously ceasing operation during unoccupied periods.

Analysis is ongoing and the project team presented preliminary results at two conferences and published results in a series of four HPAC Engineering articles. The research team also applied preliminary results to the Title 24 2005 Standards in two ways:

- Field findings helped to document problems that will be addressed through the Nonresidential Acceptance Requirements proposal.
- Modeling and analysis supported the Nonresidential Duct Sealing and Insulation proposal through PG&E's CASE initiative.

Element 5, Integrated Design of Commercial Building Ceiling Systems:

Description: The purpose of this element is to develop a

prototype integrated ceiling design system with skylights, light wells, photocontrols, electric lighting and air distribution components. To support this effort the team is:

- Conducting new tests for horizontal skylight thermal and light transmission properties, expected to lay the groundwork for long-delayed test standards for skylight/light-well combinations.
- Conducting a field study to assess the persistence and effectiveness of insulation installed on top of dropped ceilings.

Proposed Outcomes from Element 5:

- An advanced ceiling system that offers superior energy performance and lighting quality while incorporating an extremely efficient lighting system, which includes skylights and photocontrols.
- Design guidelines, ready for dissemination through the market transformation programs to designers and building owners.
- Analysis to show whether Title 24 might reasonably consider toplighting as part of baseline construction practice.
- Skylight test protocols for U factor, visible light transmittance, solar heat gain coefficient and skylight photometry.

Status of Element 5:

- Task 5.2, Lay-in Insulation: Completed analysis was used in Title 24 2005 Standards process to justify eliminating lay-in insulation as an option for dropped ceilings.
- Task 5.3, Skylight Testing: Testing is complete for solar heat gain coefficient visible light transmittance, and photometry and is in progress for U-factor. Several lighting software developers are investigating adoption of the photometry data. Additionally, the research team used the photometry results to establish in the Title 24 2005 Standards a definition of the daylit zone and skylight spacing criterion.
- Task 5.4, Integrated Ceiling System: The research team has just begun collecting information to support developing this design protocol.

Element 6, Integrated Design of Residential Ducting & Air Flow Systems:

Description: The purpose of this element is to reduce energy losses from residential HVAC duct systems. The project team will develop detailed descriptions of at least three approaches to building houses with HVAC ducts in the conditioned space (unventilated conditioned attic, dropped ceiling, or a conditioned mechanical room in the attic). The descriptions will focus on the construction techniques and details that production builders will need to incorporate to successfully utilize each approach. Specific details needed for typical single

floor, two story and townhouse homes will be developed.

Proposed Outcomes from Element 6:

- Guidelines for installing ducts within the conditioned space of three housing types.
- Documentation of energy savings potential from putting ducts in conditioned spaces.

Status of Element 6:

The research team is nearly done with the tasks of documenting alternative construction approaches, identifying ways of addressing the alternatives' market barriers, and analyzing energy savings from the various approaches. The energy savings task involved measuring duct losses in about 10 homes using several different designs.

Element 7, Outdoor Lighting Baseline Assessment:

Description: The purpose of this element is to conduct a baseline survey of current outdoor lighting technologies and their usage in buildings, parking areas, walkways and signage (not including roadway lighting) in California and to develop recommendations for improving outdoor lighting system energy efficiency. The goals of this element are to estimate the amount of energy currently used by outdoor lighting in California and evaluate its environmental impacts.

Proposed Outcomes from Element 7:

- A baseline of outdoor lighting energy usage and key environmental factors that can be used to measure the impact of any code revisions.
- Potential improvements in California's Title 24 building standards or Title 20 appliance standards or the design of new utility energy conservation programs.

Status of Element 7:

This Element was completed in late 2002. Key findings include:

- Statewide commercial and industrial outdoor lighting annual energy consumption is estimated to be 3,067 GWh (roughly 3% of the total statewide nighttime annual energy consumption).
- Statewide commercial and industrial outdoor lighting annual energy consumption is estimated to be 809 MW (roughly 3% of the peak nighttime load).
- Energy savings potential from replacing all California high-pressure sodium (HPS) lamps with metal halide (MH) lamps would save approximately 204 GWh annually.

The project results were used in justifying portions of the outdoor lighting component in the proposed Title 24 2005 standards.

Cooling Solutions

Contract #: 500-00-022 **Project #:** 6

Contractor: Gas Technology Institute

Project amount: \$100,000

Match amount: \$900,000

Contractor Project Manager: Kevin Trim (847) 768-0976

Commission Contract Manager: Chris Scruton
(916) 653-0948

Project Description: The purpose of this project is to promote the use of gas cooling technologies. Gas cooling can provide an alternative to increased peak demand for electricity for commercial cooling, particularly in the high-growth areas of California's hot, dry valleys. Applicable technologies are both absorption cooling and gas-engine-based vapor compression cycles. However, the initial costs must be driven down by RD&D and demonstrations conducted to allow commercial building architects, builders, engineers, and other decision makers the opportunity to see advanced gas cooling equipment "in action."

This project supports the PIER Program objectives by:

- Improving the reliability and quality of California's electrical supply by reducing summer peak demand;
- Improving energy cost/value by encouraging the use of natural gas during the summer when prices are low; and
- Providing greater choices for California consumers by providing new options in air conditioning technology.

Proposed Outcomes:

- Perception barriers related to Buildings Combined Heat and Power (BCHP) will be reduced.
- Decision makers will become informed through a BCHP economic study and computerized BCHP screening tool.
- HVAC designers will be educated about gas cooling.
- Members and customers will be informed about BCHP through an enhanced website.

Project Status:

- The Gas Cooling and Desiccant Dehumidification Tutorial website update is complete and has been submitted for linking to CEC website.
- Demonstrations underway of direct-fired 5-ton ammonia absorption chillers.
- Engineering educational material nearly complete.
- BCHP screening tool has been completed.
- Commercial gas cooling marketing study has been conducted.

Center for the Built Environment (CBE) Membership

Contract #: 500-01-001

Contractor: Regents - Berkeley

Contract amount: \$52,500

Contractor Project Manager: David Lehrer (510) 642-4950

Commission Contract Manager: Philip Spartz (916) 654-4592

Project Description: California Energy Commission (Commission) membership during 2002 in the university/industry/government research collaborative known as the Center for the Built Environment (CBE) enabled public funds to be leveraged for greater benefit to the citizens of the state. This collaborative, based on the University of California, Berkeley campus, performs research in the areas of energy efficiency in buildings, comfort for building occupants, indoor air quality, and productivity-conducive building environments. CBE generates beneficial building and human response data for dissemination to architects, designers, mechanical and building engineers, government agencies, and other entities that create indoor environments through a variety of research projects.

This project supports the PIER Program Objectives of:

- Improving energy cost/value of California's electricity by encouraging energy efficiency in the heating, cooling ventilation and lighting of buildings; and
- Improving the environmental, public health and safety aspects of California's electrical supply by reducing pollution associated with electricity generation through encouraging the efficient use of energy in buildings and providing more comfortable and healthier indoor environments by improving indoor air quality.

Potential Outcomes:

As a result of membership in CBE, the California Energy Commission benefits through:

- attendance at the semi-annual Industry Advisory Board meetings, providing opportunities to help direct current and future research that may impact California buildings and further energy efficiency
- direct connection with private industry and government leaders who are interested in promoting more efficient building technologies
- semi-annual project updates and copies of papers written by CBE researchers
- prioritized response and technical advice from CBE experts in areas such as underfloor air distribution, operable windows and ventilation impacts on productivity; and
- access to the members-only section of CBE's website, which contains most recent papers and other information not available to the public until after a certain time period passes.

Membership in CBE allows the Commission to leverage public-benefit research dollar expenditures for maximum benefit by combining Commission funding with funding provided by other industry and government members (called partners). The Commission's funding supports specific research as well as developing and implementing public interest R&D policies and programs that encourage well-functioning energy markets through advancements in science and pre-competitive technology that promise to enhance California's economy and/or environment.

Project Status:

Six of CBE's sixteen current projects deal with an air conditioning strategy known as underfloor air distribution (UFAD), a strategy that may result in energy and facility management efficiencies to be gained in commercial buildings. These six projects are:

- UFAD Case Studies
- UFAD Cost Analysis
- UFAD Capitol East End Block 225
- UFAD ASHRAE Design Guide
- UFAD Plenums
- FAD Stratification

The Commission membership in CBE highlighted the need of designers for further development work in the area of underfloor air distribution and was a catalyst for the software modeling work of contract #500-01-035, Modeling for Under Floor Air Distribution (UFAD).

Other current CBE projects include:

- High Performance Facades
- Mixed Mode Buildings
- Occupant Feedback
- Operable Windows
- Satisfaction Survey
- Speech Privacy
- Team Space
- Thermal Comfort Model
- Ventilation/Productivity
- Wireless Sensing

See website at <http://www.cbe.berkeley.edu/> for project-specific information and papers. The Industry Advisory Board meetings for 2003 are scheduled to be held at UC Berkeley on April 24-25, 2003, and October, 2003.

Advanced Duct Sealant Testing

Contract #: 500-01-002

Contractor: Lawrence Berkeley National Laboratory

Contract amount: \$260,000

Contractor Project Manager: Max Sherman (510) 486-4022

Commission Contract Manager: Philip Spartz (916) 654-4592

Project Description: The purpose of this project is to conduct laboratory testing and field research on duct sealing products. This research will ultimately lead to and support an American Society for Testing Materials (ASTM) standard for performance testing of the durability of duct sealants. Once a national testing standard is in place, California's Title 24 codes can be updated to refer to this performance standard. A more immediate use of this work will be to test new, advanced duct sealant products being introduced into the California home building market. This work will confirm whether or not these products meet the recently revised Title 24 code requirements for duct sealing, and, from a research perspective, the work will improve future products by understanding how current duct sealing methods fail over time.

This project supports the PIER Program objectives of:

- Improving energy cost/value of California's electricity by improving the efficiency of HVAC distribution systems, thereby reducing energy costs to homeowners; and
- Improving electricity reliability/quality/sufficiency of California's electrical system by reducing the peak demand within the residential sector, especially in new homes that are being built predominantly in hot inland climates.

Proposed Outcomes:

- Commission staff will incorporate the results of the duct sealant longevity tests into their implementation strategies for the latest Residential Building Energy Efficiency Standards.
- Future versions of California's Building Energy Efficiency Standards will be able to reference an ASTM standard for duct sealant longevity for all duct-sealing products used in California buildings.
- Other public energy efficiency programs, as well as private duct sealing practitioners, will be able to use the ASTM standard and the results of the product testing to successfully plan and implement duct sealing in California buildings.

Project Status:

Lawrence Berkeley National Laboratory (LBNL) researchers have been running a duct sealant longevity test facility at constant pressure and temperature (194°F) since January 2002, testing the performance of four different tapes on 18 different core-to-collar samples, with visual evaluations and leakage

measurements made on a monthly basis. There are two cloth-backed duct tapes, an OPP (film) tape, and a foil-butyl tape being tested. They are also considering methods of dirtying typical duct joints in a reproducible manner, possibly using sawdust and oil. A new hybrid tape, with cloth backing but using butyl rubber adhesive has also been tested. Joint leakage with this tape was found to be temperature sensitive, suggesting that duct sealant measurement protocols should take into account sample temperatures. The new tape was found to be substantially better than other cloth tapes, although possibly not as good as foil or film tapes from a longevity perspective

LBNL is also developing new sealant longevity and duct leakage test methods for ASTM. Both standards were revised based on expert comments and sent out for balloting during the summer. The ASTM committee reviewed responses in October. The temperature testing section of UL test method 181B-FX, in which tape samples are baked in an oven and then visually inspected for degradation, is also being conducted. LBNL researchers have built an oven and completed one round of this test for the four tapes used in the performance-testing task. They are also working with the tape industry to develop an estimation method for sealant product service life that is based on short-term tests and adds a quantitative factor to sealant longevity testing. Method development is currently stalled, partly because the metric to be used has not been differentiated for different applications. For example, a tape that is unacceptable for a collar-to-plenum joint might be acceptable for a core-to-collar joint, if installed with proper strapping.

Using the agreed-upon thermal conditions, simulating 30 years of duct sealant service will require two full years of testing. The contract may require an extension in time to allow testing duct sealants for a full two years.

Lighting Research Center Partners Program Membership

Contract #: 500-01-011

Contractor: Rensselaer Polytechnic Institute

Contract amount: \$150,000

Contractor Project Manager: Jennifer Brons (518) 687-7136

Commission Contract Manager: Don Aumann (916) 654-4588

Project Description: Membership in the Lighting Research Center (LRC) from 2002 through 2004 allows the California Energy Commission (Commission) to leverage public benefit research expenditures for maximum benefit by combining Commission funding with other members' funding. This Commission funding will support specific research as well as

developing and implementing public interest RD&D policies and programs that encourage well-functioning energy markets through advancements in science and pre-competitive technology that promise to enhance California's economy and/or environment.

This project contributes to the PIER program objectives of:

- Improving the reliability/quality of California's electricity system during peak load times by helping reduce lighting loads; and
- Improving environmental and public health cost/risks of California's electricity by reducing harmful NO_x emissions and CO₂ emissions resulting from electricity generation.

Potential Outcomes:

As a result of membership participation in LRC, the California Energy Commission realizes the following direct benefits:

- Priority response and advice on technical issues to Commission staff.
- Access to a special restricted area of the LRC's web site that posts research and market information only available to members.
- Complimentary advance copies of publications, reports and papers resulting from LRC research activities.
- Commission staff invitations to LRC conferences, seminars and workshops.
- Priority consideration to the Commission's request for research to be conducted in a specific area or direction within the scope of the LRC's research program, that would be beneficial to the state.
- Annual project updates and status reports.
- Privileges to obtain information through Bibliographic and database searches, and the use of LRC's Lighting Library, which includes a complete set of LRC faculty and staff publications.
- A 33 percent discount on LRC publications for future projects the Commission may choose to invest in with LRC.
- A 15 percent discount on research projects and help with finding facilities and co-funding for future projects the Commission may choose to invest in with LRC.
- A 20 percent discount on any programs offered through LRC Outreach Education Program projects the Commission may choose to invest in with LRC.
- Commission staff participation in the annual LRC Partners meeting on Rensselaer's campus, providing opportunities to:
 - meet and network with public and private sector leaders who have a national reputation in lighting
 - discuss LRC research and development achievements
 - provide input and direction for future research activities

In addition to the benefits that accrue directly to the Commission from this agreement, the following benefits will be made available from LRC to all entities that implement California's public goods lighting programs. Requests from public goods administrators for these benefits will be directed through the Commission to the LRC.

- Access to a special restricted area of the LRC's web site that posts research and market information only available to members.
- Complimentary advance copies of non-proprietary publications, reports and papers resulting from LRC research activities.
- Product testing and consulting services at cost.
- Privileges to obtain information and copies of faculty and staff publications through Bibliographic and database searches using the LRC Librarian, and the LRC's Partner-only web site, one set of NLRIP and DELTA publications, and LRC published books. Additional copies of publications may be purchased at the 33 percent Partner discount.
- A 33 percent discount on LRC publications for future projects the Commission may choose to invest in with LRC.
- A 15 percent discount on non-proprietary research projects and help with finding facilities and co-funding for future projects the Commission may choose to invest in with LRC.
- A 20 percent discount on any programs offered through LRC Outreach Education Program projects the Commission may choose to invest in with LRC.

Project Status:

LRC staff visited the Commission twice in 2002, updating Commission staff, electric utility staff, and California lighting researchers on LRC activities. Commission staff attended LRC's Partner's Day and LRC has assisted Commission staff on several technical investigations. LRC resources are available at www.lrc.rpi.edu.

Field Study of the Impacts of Underfloor Air Distribution

Contract #: 500-01-015

Contractor: California Department of General Services

Subcontractors: Center for the Built Environment

Contract amount: \$97,000

Contractor Project Manager: Teresa Kaneko (916) 323-9872

Commission Contract Manager: Martha Brook P.E.
(916) 654-4086

Project Description: The purpose of this project is to jointly fund a field study of the impacts of underfloor air distribution in

new office buildings through an Interagency Agreement between the California Energy Commission and the Department of General Services (DGS). The Capitol Area East End Complex, a recently completed state office building construction project, will be the site for this field study. The Center for the Built Environment, a research organization within the University of California, Berkeley, will conduct this field study under contract to DGS.

Underfloor Air Distribution (UFAD) systems use the open space (underfloor plenum) between the structural concrete slab and the underside of a raised floor system to deliver conditioned air directly into the occupied zone of the building. UFAD systems are typically applied in office and other commercial buildings. UFAD systems represent a highly integrated system since the supply plenum is used for the dual purposes of wiring distribution and air delivery, and diffuser layouts are closely coordinated with occupant layouts, allowing occupant interaction with the system in a way not typically possible with conventional systems.

Rarely has an innovative system concept offered UFAD's combined potential of energy savings, and health, comfort and productivity benefits. Timely research is critical to support the successful development of this important new direction in HVAC system practices and integrated building solutions. It is in the public interest to objectively evaluate the energy performance and occupant benefits of UFAD systems that are beginning to penetrate California building markets. It is important to document both the energy and non-energy benefits of this technology. This information will be useful to both public and private organizations responsible for funding commercial building construction.

This project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity to building owners and occupants by verifying the energy savings, and health, comfort and productivity benefits of innovative building energy systems.

Proposed outcomes:

This study will provide critical guidance to California for future efforts in achieving energy-efficient, sustainable, and healthy buildings. Because this will be the first state building to use underfloor air distribution, this project could have a significant and potentially long-term influence on future design, operation, and maintenance standards for state office buildings.

Project Status:

Field studies and occupant surveys have been completed to document the baseline building conditions where the state employees used to work. The construction of Block 225 is

completed, the building has been commissioned, and California Department of Education employees are now working in the building. Field studies and occupant surveys for the Block 225 building are now underway. Building system operations and occupant conditions will be monitored for the winter and summer of 2003.

Alternatives to Compressor Cooling: Phase V - Integrated Ventilative Cooling

Contract #: 500-98-024

Contractor: Davis Energy Group, Inc.

Subcontractors: University of California, Berkeley Solar Group : Loisos/Ubbelohde : Pacific Gas & Electric : ZTECH : CR Communications. :

Contract amount: \$713,246

Match amount: \$150,437

Contractor Project Manager: David Springer (530) 753-1100

Commission Contract Manager: Philip Spartz (916) 654-4592

Project Description: The purpose of this multi-year program is to reduce the peak load of new single-family homes in California transition (mild) and inland climates by eliminating compressor-based air conditioning or significantly reducing air conditioner size. Other benefits of this night ventilation cooling system include energy savings, wintertime fresh air ventilation, enhanced security, air filtration for improved indoor air quality and automatic operation that is quieter than standard forced-air systems. Previous phases of this work helped to develop "Summer Performance Home" architectural design improvements such as increased thermal mass (50% tiled slab floor and 5/8" thick drywall throughout), use of a radiant barrier in the attic, insulated slab edges, and exterior shading of south and west windows.

In this contract (the current phase of a multi-year research program), contractor Davis Energy has developed a Heating, Ventilation and Cooling (HVC) unit called "NightBreeze" that integrates heating, cooling, ventilation cooling, and fresh air ventilation. This project constructed and monitored two new homes, designed for optimal summer performance, which use the HVC unit to provide filtered cool night air to the house in lieu of or in addition to central air conditioning. The unit delivers ventilation air through heating/cooling ductwork, and includes a variable-speed fan motor that varies air volume for heating and ventilation modes, and a hot-water coil for space heating that is heated by a high efficiency water heater. A damper selects between return (recirculated) air for heating and air conditioning, and outdoor air for nighttime cooling and ventilation, and allows filtration of outdoor air.

Specialized controls, initially developed in a prior project phase,

are being improved under this project. Controls – which include a user-friendly "thermostat" -- predict next day's temperatures to provide adequate ventilation cooling while maintaining comfort and minimizing fan energy. Another project activity is the study of how adaptive comfort relates to ventilation cooling. This work is accomplished by interviewing homeowners, completing literature research, and communicating with others who are working in similar areas through the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and other venues.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by reducing peak electrical demand created by compressor-based air conditioning;
- Improving the energy cost/value of California's electricity by reducing energy use and costs created by residential space cooling during summer "heat storms" ; and
- Improving the environment, public health and safety by improving indoor air quality through the HVC unit that automatically introduces filtered cool night air into residences without the need to open windows

Proposed Outcomes:

- Improved understanding of summer performance design benefits resulting from two demonstration projects with two major builders
- Improved knowledge of where and how this technology can be applied by developing an understanding of how people operate their homes and how they adapt and respond to indoor comfort conditions
- Hardware that facilitates the cost-effective integration of night ventilation cooling, reduces summer air conditioning peak load and energy use, reduces winter fan energy use, and improves summer and winter indoor air quality
- An HVC unit with:
 - Dampers integrated with duct system for night ventilation cooling and winter fresh air ventilation
 - Fan coils that will heat the house using the domestic hot water
 - Variable speed blower motor for quiet, efficient heating and ventilation plus an optional refrigerant coil for compressor-based cooling
 - Advanced controls which convey the ventilation cooling concept to users

Project Status:

This contract is about 90 percent complete. Technology development for this contract is finished and field testing of the NightBreeze units will be completed in the second quarter of 2003. Current simulations of "NightBreeze" operation predict

average annual savings of about 500 kWh, when compared to an unventilated house that meets the minimum California Title 24 residential building efficiency standards.

NightBreeze systems have been installed in two new California homes that also incorporate the "Summer Performance Home" design features. One NightBreeze unit has been installed in a home in Watsonville (a moderate "transition" climate zone) with no vapor compression air conditioning at all. Another two NightBreeze units are installed in a Livermore home (a hot inland climate zone). The Livermore home includes two heating/cooling zones, each served by a separate NightBreeze system. Vapor compression air conditioning is controlled from the same thermostats that control heating and ventilation cooling.

Further potential development of the NightBreeze technology may allow for serving multiple zones from a single system, integration with furnace-based systems, and capabilities to provide dehumidification for more humid climates. In the future, the NightBreeze unit for inland climates may also include an optional refrigeration coil for increased cooling capacity. See website at http://www.davisenergy.com/nb_page.htm for project background, photos and product information. More information specifically on the Livermore demonstration home plus performance data can be viewed at: <http://www.fsec.ucf.edu/bldg/active/zeh/livermore/index.htm>.

Building Specification Guidelines for Energy Efficiency

Contract #: 500-98-027

Contractor: Eley Associates, Inc

Subcontractors: Taylor Engineering, Cathrine Cooper, SMWM, SDV/ACCI, After Image, John Raeber

Contract amount: \$233,280

Contractor Project Manager: Charles Eley (415) 957-1977

Commission Contract Manager: Martha Brook P.E. (916) 654-4086

Project Description: The purpose of this project is to develop reference construction specifications to encourage the use of energy-efficient equipment and technologies in commercial buildings. The focus is on efficient, cost-effective equipment and technologies that lack adequate or well-known information. This project will to lower the barriers to specifying energy efficient equipment and technologies for commercial buildings by:

- Simplifying the specifications of some technologies
- Addressing project commissioning and monitoring within

each of the technologies

- Providing specifications for advanced cost-effective technologies
- Addressing integrated controls and open protocols for commercial lighting and heating, ventilating and air conditioning (HVAC) systems
- Disseminating the new specifications to the construction industry through the Internet

Once the specifications have been tested by the Contractor's team and reviewed by building design professionals, the specifications will be made available on the Internet. The format will facilitate the use and incorporation of the specifications into construction documents by design professionals. In addition, equipment manufacturers will also understand what they need to build to satisfy the efficiency market.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by influencing standard construction practices and future building and system energy use in the commercial sector.

Proposed Outcomes:

- The specifications will promote energy efficient design of commercial buildings by providing a comprehensive and integrated source for up-to-date information on the most efficient and cost effective equipment, technologies and operating strategies.
- Reduce annual building system (e.g., lighting, HVAC) energy costs of the building whose design used the specifications by at least 5 percent.

Project Status:

The specifications are currently available for download from the contractor's website. All sections of the specifications are expected to be in a final revision by early 2003. The project should be completed by March 31, 2004.

Design Refinement and Demonstration of a Market-Optimized, Residential Heat-Pump Water Heater

Contract #: 500-98-028

Contractor: TIAX LLC

Subcontractors: EnviroMaster International (EMI), Manufacturing Associates, Pacific Plumbing

Contract amount: \$756,095

Match amount: \$153,235

Contractor Project Manager: Robert Zogg (617) 498-6081

Commission Contract Manager: Philip Spartz (916) 654-4592

Project Description: The purpose of this project is to design, test and demonstrate a market-optimized residential heat-pump water heater. The primary objectives of this project are to:

- identify and implement design refinements to lower initial and operating costs, and increase performance
- perform laboratory tests to demonstrate the durability/reliability of the design
- demonstrate the performance, reliability and ease of installation through a California-based field test

With funding by the U.S. Department of Energy, Oak Ridge National Laboratory will provide durability testing on ten prototypes under laboratory conditions simulating ten years of normal operation. The TIAX team, in cooperation with selected California utilities, will also field-test twenty prototype units in California residences.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by providing a low-cost, highly reliable and durable residential heat-pump water heater (HPWH).

Proposed Outcomes:

- Reduction of the total installed cost of residential heat pump water heaters from \$1,200 to \$875 (based on annual production volumes of 10,000 units or more)
- A heat-pump water heater capable of achieving at least a 2.0 Energy Factor, the standard performance measure for water heaters based on a test procedure prescribed by the U.S. Department of Energy

Project Status:

Cost growth both in the design and field test stages of this project caused substantial delays in 2001 and again in 2002 as the researchers obtained additional match funding and developed plans to complete the project within the existing PIER budget. In 2001, the project was strengthened with commitments by Southern California Edison, Sacramento Municipal Utility District, and Silicon Valley Power.

These California utilities are providing support for field test installations in their territories. In 2002 eighteen of twenty field test units were installed in residences or small business locations, with the last two units scheduled for installation in early 2003. The project is now scheduled to complete in the fourth quarter of 2003. Also in 2002, Arthur D. Little's Technology and Innovation business unit, which developed this heat pump water heater, was purchased by TIAX, LLC.

Results from the field test have been promising so far, with energy savings of up to 55 percent over conventional electric-

resistance hot water heaters. Manufacturer EMI has begun to market and promote the product under the "WatterSaver" brand. California's potential market share of this electric technology is about the same size as neighboring states that depend almost entirely on electric-resistance units for domestic water heating. Product information is available at http://www.enviromaster.com/watter_saver/.

Removing the Key Technical Barrier to the Widespread Use of Advanced Absorption Cooling

Contract #: 500-98-029

Contractor: Gas Technology Institute

Subcontractors: Stanford Research Institute (SRI), The Trane Company

Contract amount: \$690,178

Match amount: \$235,000

Contractor Project Manager: Kevin Krist (847) 768-0793

Commission Contract Manager: Chris Scruton (916) 653-0948

Project Description: The purpose of this project is to improve the efficiency and lower the cost of natural gas-fired absorption chillers. This project will study and support development of new corrosion resistant materials using a fluidized-bed furnace diffusion process. The new materials are expected to enable higher temperatures and efficiencies in an advanced absorption chiller, which will be tested and demonstrated as part of the project.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing the demand on the electrical system during summer peak hours; and
- Improving the environmental and public health costs/risks of California's electricity by using an absorption cycle that does not use CFCs (chlorofluorocarbons) or any other material with ozone depletion, global warming or health hazard potential

Proposed Outcomes:

A direct fired gas absorption chiller with the following features:

- Coefficient of Performance (COP) of at least 1.6
- Temperature limits of at least 285 degrees C (545 degrees F)
- Thermal conductivity of coated materials equal or better than base material
- Materials lifetime at least 20 years
- Corrosion rate of less than 01 mpy
- Coating cost of less than \$10/ft² for generators and less than \$3/ft² for absorber heat exchangers

Project Status:

The original process was developed and validated using sub-scale samples at Stanford Research Institute in Menlo Park. Quality Heat Treatment (QHT) of Australia, a leader in fluidized bed technology, is in the final stages of scaling up the technology to enable full size tube production. Broad, the world's highest volume maker of absorption chillers, has prepared a triple-effect generator at their facility in China, to test the tubes as soon as they are ready. The coating technology is also proving useful in other corrosion prone applications, such as condensing gas furnaces. The project should be completed by March 31, 2004.

Instrumented Home Energy Rating and Commissioning

Contract #: 500-98-033

Contractor: Lawrence Berkeley National Laboratory

Contract amount: \$710,000

Match amount: \$137,000

Contractor Project Manager: Max Sherman (510) 486-4022

Commission Contract Manager: Chris Scruton (916) 653-0948

Project Description: The purpose of this project is to develop residential building commissioning guidelines and to demonstrate the value of commissioning services on residences in California. The energy performance of the most significant systems and components of a building are to be evaluated, and diagnostics and audit tools developed for use in commissioning these systems and components. A set of guidelines for applying the diagnostic tools will be developed. These guidelines will lay the groundwork for a residential commissioning industry.

This project supports the PIER Program objectives of:

- Improving the energy value of California's electricity by helping consumers optimize the energy consuming systems in their home to perform at optimal efficiency;
- Strengthening the California economy by creating jobs in the commissioning field while increasing the disposable income of Californians by reducing their energy costs; and
- Improving the reliability of California's electrical supply by reducing residential peak electrical demand

Proposed Outcomes:

This project will provide information essential for developing a residential commissioning industry in California. A typical California house has 28 percent duct leakage, is 15 percent low on refrigerant charge, and has only 85 percent of needed evaporator airflow. Diagnosing and repairing the systems in this typical house will reduce electricity use by 14-18 percent

while providing a more comfortable and healthful indoor environment. Peak electrical demand will typically be reduced by 22-24 percent.

Project Status:

- The annotated bibliography on building commissioning is complete.
- The draft metrics and diagnostics report is complete.
- The laboratory and field study work is complete.
- Commissioning guidelines are complete.
- Four PAC meetings and one user workshop have been held.
- The final report is expected early 2003.

Investigation of Secondary Loop Supermarket Refrigeration Systems

Contract #: 500-98-039

Contractor: Southern California Edison

Subcontractors: Foster-Miller

Contract amount: \$300,000

Match amount: \$150,000

Contractor Project Manager: Ramin Faramarzi
(626) 633-7168

Commission Contract Manager: Chris Scruton
(916) 653-0948

Project Description: The purpose of this project is to investigate an advanced secondary loop refrigeration system for supermarkets. The system circulates a refrigerated brine solution from a chiller to refrigerated display cases. The project will identify system improvements such as variable-speed pumping, evaporative condensing, and low-head pressure operation that will reduce energy consumption. Secondary loop

refrigeration systems can significantly reduce the refrigerant charge in supermarkets, which promotes substantial environmental benefits by protecting the ozone layer and inhibiting global warming caused by loss of refrigerant from the notoriously leaky systems.

This project supports the PIER Program objectives of:

- Improving environmental and public health costs/risk of California's electricity by demonstrating an alternative refrigeration system which uses less ozone-depleting refrigerant; and
- Improving the energy cost/value of California's electricity by lowering electrical consumption of supermarket secondary loop refrigeration systems

Proposed Outcomes:

- Reduction in energy consumption for refrigeration or freezing in supermarkets by approximately 13.9 percent compared with a typical multiplex system
- Refrigerant losses at least 15 percent less than baseline system
- Overall reduction in maintenance costs compared with baseline system

Project Status:

The refrigeration equipment display cases in a supermarket in Valencia have been instrumented to measure baseline performance. A second store in Thousand Oaks with the advanced secondary loop system has also been instrumented, and the performance and energy consumption of each system is currently being monitored and compared. Monitoring and analysis will proceed through part of 2003. A final report is expected in the later part of 2003.



Characterization of Framing Factors for New Low-Rise Residential Building Envelope

Contract #: 400-00-002

Contractor: Enermodal Engineering Incorporated

Subcontractors: R. Chitwood.

Contract amount: \$61,000

Match amount: \$85,810

Contractor Project Manager: Stephen Carpenter
(519) 743-8777

Commission Contract Manager: Don Aumann
(916) 654-4588

Project Description: The purpose of this project was to extend a national survey of current residential framing practices to include California homes. This survey, sponsored by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), will help improve the accuracy of calculating overall envelope heat loss/gain. Sixty California dwellings will be audited during construction to assess the amount of framing.

More specifically, the researchers will:

- Develop a statistically representative set of framing factors for low-rise dwellings in the State of California, and
- Quantify the distribution of framing within dwellings (e.g., walls, windows, ceilings)

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by improving the energy efficiency of residential dwellings

Proposed Outcomes:

- Revised framing factors for California homes
- Suggestions for changes to Title 24

Project Status:

The project is completed. The final report (P500-02-002) was completed in early 2002.

Actual Outcomes:

The research team found that framing factors in California were very similar to those in the national survey and that little additional framing is used in California to meet seismic requirements. More specifically, framing factors (net of windows, doors, skylights, etc.) for new California homes are:

- 7 percent ceiling
- 27 percent wall
- 15 percent overall

The results are included in the proposed 2005 Title 24 revisions, which specify a 25 percent framing factor for walls.

Lighting Research Center Partners Program Membership

Contract #: 400-99-017

Contractor: Rensselaer Polytechnic Institute

Contract amount: \$50,000

Contractor Project Manager: Jennifer Brons (518) 687-7136

Commission Contract Manager: Don Auman (916) 654-4588

Project Description: Membership in the Lighting Research Center (LRC) during 2001 allowed the California Energy Commission (Commission) to leverage public benefit research expenditures for maximum benefit by combining Commission funding with other members' funding. The Commission's funding will support specific research as well as developing and implementing public interest RD&D policies and programs that encourage well-functioning energy markets through advancements in science and pre-competitive technology that promise to enhance California's economy and/or environment.

As a result of membership participation in LRC the California Energy Commission realizes the following benefits:

- Participation in the annual LRC Partners meeting, providing opportunities to help direct future research.
- Working relationships with LRC staff and industry leaders.
- Priority response and advice on technical issues to CEC employees.
- Access to a special restricted area of the LRC's website that posts research and market information only available to members.
- Complimentary advance copies of publications, reports and papers resulting from LRC-funded research activities.
- Priority consideration to the Commission's request for research to be conducted in a specific area or direction within the scope of the LRC's research program, that would be beneficial to the state.
- Annual project updates and status reports.
- Privileges to obtain information through Bibliographic and database searches, and the use of LRC's Lighting Library, which includes a complete set of LRC faculty and staff publications.
- Discounts on LRC publications and research projects.

This project contributes to the PIER program objectives of:

- Improving the reliability/quality of California's electricity system during peak load times by helping reduce lighting loads.
- Improving environmental and public health cost/risks of California's electricity by reducing harmful NO_x emissions and CO₂ emissions resulting from electricity generation.

Project Status:

This contract is now completed.

Actual outcomes:

LRC staff participated in two on-site visits, updating Commission staff on lighting research and technology developments. Additionally, LRC provided:

- A thorough technical review of the Commission's recently-released Advanced Lighting Guidelines
- Quick response to Commission staff questions about CFL impacts on the grid
- Insider information covering ongoing research such as a self-commissioning photosensor
- An opportunity for Commission staff to interface with the manufacturers of lighting products and to solicit industry input on lighting research issues. In October 2001 the California Energy Commission approved a \$150,000 contract (#500-01-011) to extend the LRC organizational membership from 2002 through 2004.

Increased Energy Efficiency of Refrigerators and Air Conditioners Through Use of Advanced Power Electronics

Contract #: 500-98-021

Contractor: Energy Savers International

Subcontractors: Lawrence Berkeley National Laboratory (LBNL) : Ed Vineyard : Hybrid Circuits, Inc. : Sun Frost : Bristol Compressors : Robert Lynette. :

Contract amount: \$411,614

Match amount: \$114,714

Contractor Project Manager: T. Jayadev (408) 257-6465

Commission Contract Manager: Philip Spartz (916) 654-4592

Project Description: The purpose of this project was to develop an energy-efficient electronic control system by which refrigerators and air conditioners with single-phase compressor motors could be operated more energy efficiently using three-phase motors. Because three-phase motors are more efficient and less costly to manufacture, there was a significant potential for reducing the electrical consumption of conditioners and other residential appliances. In addition, this project was expected to help decrease the load energy consumption of air conditioners that have a significant effect on peak loads.

Successful completion of this project was expected to increase the efficiency of residential refrigerators by approximately 19 percent, with no increase in cost to consumers. The technology would be applicable to other residential appliances that use single-phase motors such as air conditioners, heat pumps, washing machines and clothes dryers, and promised

potentially huge energy savings for such appliances.

This project supported the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by making an existing energy technology more efficient, thereby lowering the cost of electricity for cooling and electric heating to residential customers
- Improving the reliability/quality of California's electricity by helping to reduce peak electrical demand from residential cooling

Proposed Outcomes:

- Development of an electronic control system that allows three-phase compressor motors to operate on single-phase electrical power. Operation with three-phase power significantly reduces electric motor conversion losses, so that the use of three-phase motors for residential applications will be economically feasible.
- Demonstrate a 30 percent increase in efficiency for a typical domestic refrigerator compressor by improving the energy efficiency ratio (EER) from 5.4 to 7.0.
- Demonstrate a thirty percent increase in efficiency for a typical domestic heat pump compressor.

Actual Outcomes:

- Comparison of predicted refrigerator compressor efficiency increases (only 10 percent) and predicted unit cost did not justify designing power electronics for this application, so work was shifted to focusing on domestic heat pumps instead.
- For domestic heat pumps and air conditioners units equipped with multiple-speed, three-phase compressor motors, efficiency increases of 30 percent were predicted, when compared to units with single-speed, single-phase motors.
- A combined electronic power supply/three-speed controller was designed and built that easily fits inside existing cabinets of heat pumps or air conditioners
- This improves on mechanical multi-speed technology, which is often quite bulky.
- The prototype combined power/controller unit proved to have a low power factor. Although adding a filter circuit would improve performance, cost factors precluded such development. A commercial power supply was used instead and research was then focused specifically on developing an electronic controller.
- Estimated phase conversion efficiency increases for an air conditioner in going from single-phase to three-phase power were found to be on the order of 4 percent.
- Measured speed conversion efficiency increases for an air conditioner going from single-speed to three-speed

operation were about 19 percent when using the default degradation coefficient in ARI standard 210/240-94 of 0.25.

- Estimated controller costs for residential heat pumps or air conditioners is approximately \$100/ton, installed
- for units 5 tons and above, approximately \$80/ton.
- Laboratory testing of the heat pump electrical performance verified that lower compressor motor speed reduced unit power requirements proportionately.
- Although full-load air conditioner operation at high temperature (105°F) did not improve unit efficiency, the controller developed through this research can operate the air conditioner at reduced speed and proportionately reduced electrical demand. For example, half-speed operation dropped power requirements from 5.5 kW to 2.5 kW.

Project Status:

This project was completed December 19, 2001. The contractor has demonstrated that power electronics can increase the energy efficiency of domestic heat pumps and air conditioners and is pursuing further market connections.

Evaluate Small Commercial Air Conditioning Units for Northern/Central California

Contract #: 500-97-010

Contractor: Pacific Gas and Electric (PG&E)

Contract Amount: \$500,000

Contractor Project Manager: Lance Elberling (925) 866-5519

Commission Contract Manager: R. Michael Martin (916) 654-4039

Publication Number: P600-00-023

Project Description: This purpose of this project was to:

- Identify those technologies that can potentially improve the energy efficiency of air conditioning applications using rooftop packaged air conditioners on small commercial buildings in hot-dry climates;
- Document the actual performance of two selected technologies through laboratory testing over a range of operating conditions; and
- Provide this information to the HVAC market to encourage the adoption of appropriate technologies.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing electricity customers in the commercial sector with information on energy-efficient options to cool their facilities.

Proposed Outcome:

- Identify several technologies that could potentially improve

the energy efficiency of air conditioning technologies with sufficient detail to enable specifiers of equipment to make good informed choices.

Actual Outcome:

- Documented several such technologies, with detailed information about performance of two such technologies at a variety of outdoor temperature and humidity conditions.
- Used evaporative condenser precoolers that resulted in greater energy savings in hot dry climates at greater initial cost and is recommended for retrofit applications.
- Used conventional design high efficiency air conditioners with dual compressors which had more modest performance improvements at a lower additional first cost and is recommended for new applications.

Improve the Cost Effectiveness of Building Commissioning Using New Techniques for Measurement, Verification and Analysis

Contract #: 500-97-010

Contractor: Pacific Gas and Electric (PG&E)

Subcontractors: Schiller Associates; ESS Engineering Inc.; and the Joint Center for Energy Management

Contract Amount: \$300,000

Contractor Project Manager: Steve Blanc (925) 866-5570

Commission Contract Manager: Joseph Wang (916) 654-4026

Publication Number: P600-00-024

Project Description: The purpose of this project was to investigate and demonstrate cost-effective and energy-efficient methods for the commissioning of medium to large buildings that have complex mechanical, lighting, and energy management control systems. Commissioning would insure that buildings designed for maximum energy-efficiency perform as intended, thereby reducing energy costs associated with building operations.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by developing tools to analyze, and guarantee, the performance of energy-efficiency measures.

Proposed Outcomes:

A major obstacle to wide-spread adoption of building commissioning is cost. This project created commissioning techniques more effective and less costly to implement. These techniques were tested in a laboratory and a demonstration site to evaluate their performance. The system included high-quality sensors, a knowledge base to identify system failure, automated

communications and data management and data visualization to diagnose building energy performance problems. In addition, the project developed:

- Specifications for a building fault detection and diagnostics technique that would provide a platform for further commercial development and provide information needed to automate the diagnosis of building energy performance problems;
- A commissioning tool which would focus on the identification of minimum historical data requirements necessary to accurately predict cooling system performance in a typical commercial building; and
- A measurement and verification tool that would allow users to evaluate different measurement scenarios to determine cost effectiveness for specific energy-efficiency measure.

Actual Outcomes:

- Developed a model-independent, fault detection and diagnostics for variable air volume terminal units. This commissioning tool is based on the use of a residual approach to develop fault detection and diagnostics tool preprocessors. This avoids the traditional use of model based approach requiring that a tool be calibrated using large amount of historical data.
- Developed a first principles model for integrated cooling systems. This tool focuses on the identification of the minimum historical data requirements necessary to accurately predict cooling system performance in a typical commercial building.
- Developed a building automation control network (BACnet)-based control system driver to facilitate fault detection and diagnostics (FDD) in open architecture energy management control systems. This tool is a generic communications interface for controls systems employing BACnet gateway open protocols. This allows building operators access building data with any building control systems.
- Developed a measurement and verification value tool that is a data base-driven program that allows the user to evaluate different measurement and verification scenarios to determine cost and saving uncertainty for specific energy efficiency measures.

Improve the Cost Effectiveness of Building Control Systems Sensing and Data Collection

Contract #: 500-97-010

Contractor: Pacific Gas and Electric (PG&E)

Contract Amount: \$250,000

Contractor Project Manager: Steve Blanc (925) 866-5570

Commission Contract Manager: Joseph Wang
(916) 654-4026

Publication Number: P600-00-025

Project Description: The purpose of this project was to investigate methods to reduce the costs of current energy-management systems, such as low-cost building control systems and sensors. Energy management systems allow utility customers to monitor and control their energy consumption and improve the energy-efficiency of the whole building.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by providing utility customers with tools that could help reduce their energy consumption.

Proposed Outcomes:

- Develop a method for determining the accuracy and storage frequency needed for various data acquisition functions in commercial HVAC systems, and
- Specify the use of economics (costs versus benefits) and operating needs to determine accuracy and storage frequency for data collected from commercial HVAC systems.

Actual Outcomes:

- PG&E developed a method for determining the accuracy and storage frequency required for various data acquisition functions in commercial HVAC systems.
- PG&E demonstrated the method on an example building under two different weather profiles (focusing on the air-handling equipment and chilled water temperature) and showed the potential benefits when more accurate equipment and better diagnostic techniques are used.
- PG&E repeated the analysis on several other building types and sizes using a different energy simulation model. The result is a range of recommended measurements, storage frequencies, and potential energy savings for buildings with different annual energy uses.

Residential Thermal Distribution Systems

Contract #: 500-97-013

Contractor and Major Subcontractors: California Institute for Energy Efficiency; Lawrence Berkeley National Laboratory; ConSol Consulting

Contract Amount: \$400,000

Contractor Project Manager: Karl Brown (510) 642-7545

Commission Contract Manager: Dale Trenchel
(916) 654-4098

Publication Number: P600-00-002

Project Description: The purpose of this project was to develop new knowledge and prototype technologies that would improve the energy-efficiency and performance of heating, ventilation and air conditioning (HVAC) equipment in

residential buildings. The work included developing and testing the effectiveness and durability of duct sealant technologies for use in residential buildings. New methods of measuring duct leakage were evaluated, and interactions between equipment sizing and the effectiveness of the distribution system to deliver cooling throughout a home were analyzed. A significant issue investigated was the ability of downsized equipment and good distribution systems to deliver the same cooling benefits as larger, typical HVAC systems, but at a lower cost to the consumer.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California’s electricity by providing information, tools and products to reduce HVAC energy consumption in residential buildings. Specifically, this project will develop new procedures to evaluate the longevity of sealants used on residential HVAC ducts and new test methods for measuring energy losses through duct leakage. These results make possible the reduction of electricity for home heating and cooling use in residential HVAC systems through better duct sealing measures, reduced equipment sizing and improved diagnostics.

Proposed Outcomes:

- Improve duct leakage test methods.
- Update the American Society for Testing and Materials (ASTM) Standard E1554 – *Determining External Air Leakage of Air Distribution Systems by Fan Pressurization*.
- Develop and introduce a draft ASTM standard for longevity testing of duct sealants.
- Measure the performance of residential cooling equipment and associated distribution systems.
- Compare the REGCAP simulation model to the measured field data.
- Provide technical support to the Energy Commission for updating the *Low-Rise Residential Alternative Calculation Method Approval Manual for 1998 Energy Efficiency Standards for Low-Rise Residential Buildings (CEC 1999) and Procedures for HVAC System Design and Installation* (for HERS).
- Support ASHRAE, ASTM and U.S. EPA duct leakage research and interface with projects funded by other agencies.

Actual Outcomes:

- This investigation yielded a new duct leakage test called DeltaQ.
- The existing ASTM Standard (E1554) for measuring duct leakage has been rewritten and submitted to the ASTM standards review process.
- A draft ASTM standard for longevity testing of duct sealants was developed. A draft was submitted to ASTM

subcommittee E06.41 for balloting and comment. The comments on the draft resulted in changes to the test method and apparatus. A new test apparatus was constructed with funding from the U.S. DOE.

- Simulations of summer temperature pulldown time have shown that duct system improvements can be combined with equipment downsizing to save first cost, energy consumption, and peak power and still provide equivalent or superior comfort.
- Air conditioner name plate capacity ratings alone are a poor indicator of how much cooling will actually be delivered to the conditioned space. Duct system efficiency can have as large an impact on performance as variations in Seasonal Energy Efficiency Ratio (SEER). Installing high SEER units can reduce energy consumption with no apparent drawbacks.
- Duct efficiency calculations are included in the *Low-Rise Residential Alternative Calculation Method Approval Manual for 1998 Energy Efficiency Standards for Low-Rise Residential Buildings* (CEC 1999).
- Procedures for HVAC System Design and Installation (for Home Energy Raters) have been updated.
- Field-testing has shown that standard flowhoods can be poor for measuring residential register flows.

Commercial Thermal Distribution Systems

Contract #: 500-97-013

Contractor and Major Subcontractors: California Institute of Energy Efficiency (CIEE) and Lawrence Berkeley National Laboratory (LBNL)

Contract Amount: \$400,000

Contractor Project Manager: Karl Brown (510) 643-1617

Commission Contract Manager: Mazi Shirakh (916) 654-3839

Publication Number: P600-00-004

Project Description: The purpose of this project was to develop information and products that would improve the energy-efficiency and performance of heating, ventilation and air conditioning (HVAC) equipment in commercial buildings. This project assessed the performance of air-duct systems in California’s commercial buildings, developed and tested duct-sealant and duct-encapsulation technologies specifically for applications in commercial buildings, and developed tools to diagnose the energy-performance of commercial building fan systems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California’s electricity by reducing peak demand and improving load factor, leading to reduced infrastructure costs and system reliability risks;

- Improving the energy cost/value of California's electricity by improving thermal performance of the commercial thermal distribution systems. Current data suggests that leakage in commercial thermal distribution systems is in excess of 20 percent, with additional excess energy use caused by fan system problems; and
- Improving the environmental and public health costs/risks of California's electricity by improving indoor air quality through improved control of air flows and duct encapsulation technology.

Proposed Outcomes:

- Advance knowledge about performance and losses for commercial building thermal distribution systems.
- Evaluate the potential for reducing thermal losses through duct sealing, duct insulation, and improved equipment sizing.
- Advances in innovative techniques for sealing ducts and encapsulating internal duct insulation.
- Advances in protocols and techniques for testing, analyzing and diagnosing energy-related problems in large commercial building fan systems.

Actual Outcomes:

- Identified significant duct leakage in large commercial buildings, with large associated energy losses.
- Confirmed significant potential energy savings from duct sealing in large commercial buildings and identified building model enhancements that will allow incorporation of duct performance improvements in building energy standards.
- Improved prototype equipment and field experience for duct sealing and encapsulation technology.
- Made advances in tracer gas measurement techniques and refined protocols for diagnosing energy losses in large building fan systems.

Diagnostics for Building Commissioning and Operations

Contract #: 500-97-013

Contractor and Major Subcontractors: California Institute for Energy Efficiency (CIEE) and University of San Diego; SuperSymmetry; Stanford University and Jones Lang Wootten: California Inc.

Contract Amount: \$350,000

Contractor Project Manager: Carl Blumstein
(510) 642-9590 ext.202

Commission Contract Manager: Joseph Wang
(916) 654-4026

Publication Number: P600-00-005

Project Description: The purpose of this project was to demonstrate a system that allows building occupants to monitor the energy use within their building, so they may determine if the building is performing at its optimum energy-efficiency level. This system will permit building occupants to improve the energy-efficiency of their buildings by facilitating the identification of energy performance problems.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by helping customers optimize their building systems to perform at their peak energy efficiency.

Proposed Outcomes:

This project was to demonstrate an advanced operator information, monitoring and diagnostics system (IMDS) for whole-building commissioning and operations. The system and project objectives included:

- High-quality sensors.
- Knowledge base to identify system failure.
- Automated communications and data management.
- Data visualization to diagnose building energy performance problems.
- Evaluating the energy savings and other non-energy benefits of IMDS use. The objective is to reduce total energy use and energy cost by 15 percent without sacrificing any other building services or performance issues.
- Developing and demonstrating techniques to automate fault detection and diagnosis using a steady-state chiller model and evolutionary programming for self-learning systems.
- Evaluating the decision making and technology adoption processes in the commercial buildings sector.

Actual Outcomes:

- LBNL successfully demonstrated that the IMDS is very useful in evaluating the building's performance. The building operators perceive significant improvements in the performance of the building. These include improvements in control, reduced comfort complaints, and the identification of significant energy savings. Even more significant is that the IMDS has been useful in identifying an ongoing set of problems at the building that are related to problems inherent in the control systems.
- LBNL developed a prototype stand-alone chiller data analysis tool was developed to provide the operations staff with additional diagnostic capabilities beyond the IMDS. However, neither the chiller diagnostic tools nor the utilization techniques are mature at this point.

Building Design Advisor

Contract #: 500-97-013

Contractor: California Institute for Energy Efficiency (CIEE)

Contract #: 500-97-013

Contract Amount: \$350,000

Contractor Project Manager: Konstantinos Papamichael
(510) 486-6854

CIEE Project Manager: Carl Blumstein (510) 642-9590 ext.202

Commission Contract Manager: Tav Commins
(916) 653-1598

Publication Number: P600-00-008

Project Description: This project updated the Building Design Advisor (BDA), a Windows-based computer program that facilitates decision making through integrated use of multiple analysis tools and databases. This tool, when completed, will enable building designers to consider various energy efficiency options during the design stage of new buildings, when energy efficiency measures are typically more cost effective. The main deliverable for this project was to integrate DOE-2 into the tool. DOE-2 is a building energy simulation program that is the industry standard for producing detailed and accurate energy performance simulations.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by allowing energy-saving measures to be integrated into the early design of a building, thereby making energy-efficient measures more cost effective.

Proposed Outcomes:

- Bring the initial BDA software from an unstable, incomplete Beta release to a robust 1.0 version for distribution to academia and the building industry for evaluation and feedback.
- Develop an updated 2.0 version with links to DOE-2. This will demonstrate the expandability of the BDA software to include links to simulation tools already accepted and trusted by the building industry and make the BDA more appealing for use in actual projects.
- Elicit industry feedback to identify industry needs and desires, towards BDA versions that will be appropriate for use in actual projects.
- Prepare a commercialization strategy for widespread distribution of the software with proper user support.
- Initiate developing a BDA-based Issue Based Information System (IBIS) that will facilitate the use of the BDA as a collaborative, concurrent design tool, and greatly enhance developing links to tools that address the whole building life cycle, from design through construction and commissioning, to operation and eventual demolition.

Actual Outcomes:

- The BDA 1.0 has been in distribution since January 1999, free of charge through the Internet. To date, more than 450 reviewers have downloaded the software from the project's Web site. Approximately 150 reviewers are from academia (professors and students) and 300 are from the building industry (architects, engineers, energy consultants, etc.).
- Beta releases of BDA 2.0, with links to DOE-2, were used in workshops with architects and engineers in the San Francisco, Los Angeles, and Sacramento areas. Useful comments were elicited through extensive interactions between the software developers and the building industry participants. Comments and suggestions were organized and prioritized based on workshop participants input.
- The response to the BDA concept has been enthusiastic and has resulted in very useful feedback on the specific needs of building design professionals. Several university professors plan to use the BDA software in relevant architectural and engineering courses.
- A commercialization report was prepared.
- The design of the BDA-based IBIS was completed, with potential use scenarios and graphical user interface elements for implementation in future versions of the BDA software.

Alternatives to Compressor Cooling

Contract #: 500-97-013

Contractor: California Institute for Energy Efficiency (CIEE)

Contract Amount: \$350,000

Contractor Project Manager: Karl Brown (510) 486-5338

Commission Contract Manager: Randel Riedel
(916) 654-4109

Publication Number: P600-00-003

Project Description: The purpose of this project was to develop and evaluate house designs capable of providing comfort in California transition climates without the use of conventional compressor-based cooling. Compressor-based cooling is growing rapidly in transition climate zones inland from major California coastal urban centers. However, the low hours of air conditioning use in these areas create an extremely poor load factor with a substantial adverse effect on costs of service and electric system operations.

Compressor-less cooling will result in energy and peak demand savings in the warmer climate zones in California. With the highest practical market penetration, the potential avoided increase in new electric demand is estimated to be 0.5 Watt per square foot of new house area averaged across all new residential construction. The equivalent potential in retrofit is estimated to be one Gigawatt in California. Load factors would

be improved with a substantial increase in system reliability and decrease in cost of service. In addition, air-conditioning system size will be reduced in more severe climates through the adoption of project design concepts.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing peak electrical demand created by compressor-based air conditioning; and
- Improving the energy cost/value of California's electricity by reducing energy use and costs created by residential space cooling during summer "heat storms."

Proposed Outcomes:

- Evaluate pilot houses and/or subdivisions using project-developed house designs.
- Develop a prototype cost/capability-optimized alternative cooling system controller.
- Provide technology transfer through design information dissemination, assistance, and evaluation.
- Promote the project with design competitions.
- Develop applications information to assist market transformation programs.

Actual Outcomes:

Evaluate pilot houses and/or subdivisions using project develop house designs.

- A Northern California prototype house design was developed.
- A Southern California prototype house was modified and a variation with street access to the garage was designed. Builders and developers in California were solicited to initiate a pilot house or subdivision program. Everyone contacted was interested in the prototype concepts and designs, but were unwilling or unable to commit to building a pilot project.
- An expanded definition of "comfort" and the impact of Time of Use charges were both found to support the technology concept of the compressorless cooling design.
- The Northern California prototype house performance simulation was not completed so applications and sizing information is based on the results from the Southern California house. The Northern California house is expected to perform even better.
- Performance simulations demonstrated that compressorless technologies will not maintain comfort in the Southern California prototype house in all California transitional climates. However, a substantially downsized compressor (1.5 tons) operated in concert with the night ventilation and house design will maintain comfort in all transitional climate

areas and in all but the most severe hotter inland climates. The performance simulations for this phase of the ACC project have been re-checked and are correct.

- Appraisers indicated that the disadvantages of a smaller compressor or no compressor would be offset by the superior construction of this particular type of residence. However, they would prefer to make their determination of energy tradeoffs based on an existing model for comparison with standard designs and construction.

Develop a prototype cost/capability-optimized alternative cooling system controller.

- A prototype low energy cooling control system to enable operation of the house for night ventilation was developed and tested in two houses. The result was a demonstrated reduction in compressor cooling use while comfort was maintained in a moderately hot climate.
- Based on occupant interviews, the user interface was successfully used by the occupants to maintain comfort and reduce compressor use during an overheated period.
- Occupants were able to operate the controller effectively although they did not necessarily understand the technical details of the mechanical system.
- Feedback from the controller web page simulation confirmed the usefulness of the comfort range strategy in the interface design and identified modifications to the interface that will be revised in the next phase.

Provide technology transfer through design information dissemination, assistance, and evaluation.

- The PIER research team presented the house designs, control design and program concepts to many individual builders, developers, architects and owners.
- The house designs were presented in more formal venues including: Los Angeles Department of Water and Power in regard to Playa Vista Development, the San Diego Regional Energy Office, LBNL Noon Lecture Series, CIEE Tri-annual Review, NAHB Green Building Conference, Green Building Challenge Conference, poster session at the PIER Conference "Energy Innovations '99", and to the following individuals in Washington, D.C.: Rich Karney (DOE), Mark Ginsberg (FEMP Director), George James (Building America), Larry Zarker (PATH), Sam Raskin (ENERGYSTAR Homes, EPA), Mark Nowak (NAHB Research Center).
- The following publications were produced: *Smart Thinking About Smart Houses, and Ventilation Cooling Without Losing Control.*

Promote the project with design competitions.

- In 1999, a professional slide show and script on the concepts and prototype designs were developed and presented during

the "Gold Nugget Awards" held at the annual Western Building Show.

- Two custom homes with low energy cooling, shading, thermal mass and night ventilation received the "1999 Summer Performance Awards".

Develop applications information to assist market transformation programs. Current trends in the residential industry which are complementary with compressorless strategies provide opportunities for market adoption. These include interest in "green buildings", "new urbanism", "concern for indoor air quality, health and environment", Energy Efficient Mortgages, and the embracing of "quality" as a marketing strategy.

High-Efficiency Lighting Torchieres

Contract #: 500-97-013

Contractor and Major Subcontractors: California Institute of Energy Efficiency (CIEE) and Lawrence Berkeley National Laboratory(LBNL)

Contract Amount: \$90,000

Contractor Project Manager: Carl Blumstein
(510) 642-9590 ext.202

Commission Contract Manager: Mazi Shirakh
(916) 654-3839

Publication Number: P600-00-006

Project Description: This purpose of this project was to develop portable, high-efficiency, indirect torchiere fixtures that would use one of the next generation high-efficacy electrodeless or electroded fluorescent lamps. These fixtures are targeted at the commercial office interiors where there is a demand for high color quality and low-glare portable lighting. This proposed effort was a first step in the development and demonstration of new office torchiere lighting systems. Wide adoption of the technology developed in this project would significantly increase the penetration of high-efficiency fixtures in commercial interiors.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by improving the efficacy of the very popular torchieres. Incandescent torchieres are very inefficient and present a fire hazard. The proposed advanced torchieres reduce electrical consumption by 75percent.

Proposed Outcomes:

- Produce prototype fixtures that exploit the properties of the next generation of high efficiency advanced fluorescent lamps and advanced optical reflectors.

- The prototypes were expected to have high color quality and low glare suitable for use in commercial office spaces

Actual Outcomes:

- The LBNL contract discusses high efficiency lamps with efficacies in the range of 83 to 100 lumens per watts. The actual outcome was lamps with efficacies in the 72 to 79 lumens per watt. The commercially available lamps currently have efficacies in the 55 to 69 lumens per watt.
- The proposed lamps have color temperatures and color rendering indexes that are comparable or superior to what is commercially available.
- LBNL also experimented with different types of optical reflecting materials, determining that white paint is the most practical due to cost considerations.
- The retail costs are expected to be around \$60-\$70 a unit which is competitive with what is available now (which is around \$50-\$60 for high-end products).
- Currently there are no torchieres with the upright/downlight components and with the range of efficacies discussed above.

CIEE Collaborative Program Planning and Management

Contract #: 500-97-013

Contractor: California Institute of Energy Efficiency (CIEE)

Contract Amount: \$600,000

Contractor Project Manager: Jim Cole (510) 486-4123

Commission Contract Manager: Gary Klein (916) 653-8555

Publication Number: P600-00-001

Project Description: The purpose of this project was to coordinate the efforts undertaken in the eight CIEE Transition solicitation projects. The project was to provide planning, funding, management and technology transfer activities for these projects. CIEE was the primary link between the Commission's contract managers and the principal investigators. CIEE was to ensure that the administrative and reporting requirements of each project were met.

CIEE was scheduled to release a Request for Proposals (RFP) for the first phase of a new multi-year project known as the Market Transformation Research: New Commercial Buildings Project. This new project was to have been managed by CIEE. CIEE was to maintain an Internet web site that contains information on the Commission-funded Transition Solicitation projects as well as integrate technology transfer activities into the transition project activities.

Proposed Outcomes:

- Manage the research and development of the new end-use

efficiency technologies emphasized in CIEE projects.

- Coordinate with the research teams, the CIEE Research Board and other Sponsor representatives in exploring the initial market applications of the new energy efficiency technologies.
- Conduct a review of the CIEE R&D program by independent peer review panel.

Actual Outcomes:

- Final report for each project produced.
- CIEE recommended the establishment of a statewide, coordinated Emerging Technologies Initiative to the California Board for Energy Efficiency (CBEE) and the California Public Utilities Commission (CPUC) in June and July of 1999.
- CIEE, in collaboration with Energy Commission staff and CIEE Sponsor representatives, prepared and issued a Request for Proposals (RFP) to select a research team and detailed research plan for the CIEE multiyear project: Market Connections for New Commercial Building Technologies.
- CIEE collaborated with Southern California Gas and other CIEE Sponsor representatives in planning and funding two public interest R&D projects involving low NO_x, energy efficient combustion of natural gas in industrial, commercial and other market applications.
- Independent peer review conducted in April 1999, concluded that the overall quality of CIEE's R&D program was outstanding.

Target 1 Residential Heat Pump Technology

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; D.W. Abrams, P.E. & Associates; P.C.; OG&E Electric Services Company; Oregon Department of Energy; Saturn Resource Management; Southern California Edison Co.

CEC Project Amount: 1999: \$293,697

Match Funding: 1999: \$1,129,818

Contractor Project Manager: Carl Hiller, 530/758-3035

Commission Project Manager: Bill Pennington,

Commission Contract Manager: Gary Klein, 916/653-8555

Project Description: The purpose of this project is to support EPRI's continuing development of high-performance (energy efficient) heat pumps and their efforts to deliver quality data and services to invigorate the market. Working with manufacturers and research partners, EPRI is supporting production of climate-wise air and geothermal heat pumps, demonstrating heat pump applications, verifying performance and energy efficiency, and pursuing refinements to the "Insider" heat pump, a compact unit for multifamily and

manufactured housing. This target also delivers products on duct system design and duct sealing technology to further reduce energy waste, and collaboration on a national technician certification program to address installation and customer satisfaction issues.

EPRI's collaborative program impacts technology development and heat pump infrastructure nationally. This, in turn, benefits California users to ensure a continued positive market environment for residential heat pumps. The Commission will receive technical information and persuasive promotional materials for local educational activities to stimulate residential customer's interest.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing and enhancing the performance and efficiency of residential heat pump technology to reduce the energy needs for space heating and cooling applications; and
- Improving the environmental and public health costs/risks of California's electricity by reducing energy use, which in turn decreases power generation emissions, and by supporting the changeover from ozone depleting refrigerants to Zero Ozone Depletion Potential (ZODP) fluids.

Proposed Outcomes:

1. Provide tools to increase the use of Zero Ozone Depletion Potential (ZODP) Refrigerants.
2. Provide tools to increase the potential for the use of Air-Source Heat Pumps.
3. Provide information to support market-ready enhanced, integrated heat pumps.
4. Develop a Technician Certification program to improve the likelihood of proper heat pump selection and proper installation.
5. Supply information to increase the potential for use of Ground-Source Heat Pumps (GHP).
6. Compile information to increase the potential for use of Thermal Distribution Systems Development and Applications.
7. Conduct a Tailored Collaboration entitled "Research on Heat Pump Performance Maps for Incorporation into Building Energy Analysis Calculation Methods" to develop improved calculation methods that permit more accurate comparison of standard air-source heat pumps and air conditioners with ground-source heat pumps.

Actual Outcomes:

1. Software and information were provided on the performance of zero ozone depletion potential refrigerants.
2. Air-source heat pumps.

- Version 1.0 was released of EPRI's ESPRE for Windows, which can be used to analyze building energy use as a function of technology.
 - Version 3.0 was released of EPRI's Residential Desk Book, which offers a compendium of information of end-use residential technologies.
 - Brochures were published on dual fuel heating and cooling, sealing heating and cooling systems, and repairing leaky ducts.
 - A newsletter was published on heat pump developments, issues, and markets.
3. Integrated heat pumps.
 - Support was provided to the manufacturer of the PowerMiser integrated heat pump.
 - A brochure was published on marketing integrated heat pumps
 - A brochure was published on the Insider integrated heat pump.
 4. EPRI assisted in the development of a comprehensive technician certification program, which merged the testing and certification programs of NATE, ACCA, and RSES.
 5. Ground-source heat pumps (GSHPs).
 - A design and installation planning guide was published for GSHPs.
 - A directory was published of GSHP manufacturers and equipment.
 - EPRI hosted the 1999 GeoExchange Industry Conference and Exposition in Sacramento in September 1999.
 6. A brochure was published on optimizing thermal distribution systems.
 7. Detailed performance map data were collected on both air- and ground-source heat pumps for use in an upgraded analytical procedure to be used in California Title 24 residential building energy compliance evaluations. Several thousand performance maps were obtained, and recommendations were made on analytical procedure modifications.

Status:

The Commission's participation in this target ended as of December 31, 1999. Participation in the tailored collaboration ended December 2000.

Target 9 Commercial Building Thermal Storage

Contract #: 100-98-001 #1

Contractor and Major Subcontractors: EPRI; Florida State Energy Center; University of Wisconsin

CEC Project Amount: 1999: \$40,000

Match Funding: 1999: \$268,999

Contractor Project Manager: Mukesh Khattar 650/855-2899

Commission Project Manager: Martha Brook

Commission Contract Manager: Gary Klein 916/6538555

Project Description: The purpose of this project is to continue developing and implementing thermal energy storage (TES) technology. TES is valued for its proven capacity to trim peak power costs and reduce chiller capacity requirements, often resulting in systems more economical overall than their non-storage counterparts. This can reduce California ratepayers' electric bills and stretch California electric generation capacity. The importance of these advantages is accentuated by the emergence of refrigerant phaseout issues and real-time pricing. Many customers with facilities well suited to thermal storage are hesitant to move ahead because TES is sometimes seen as an unknown technology.

This project focuses on development of easy-to-use controls for optimal system operation, new analysis methods and data to improve the use of thermal storage in conjunction with real-time pricing, and technology demonstrations to build confidence and use of the technology.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by through development and application of thermal energy storage systems, which can reduce energy bills of California ratepayers.

Proposed Outcomes:

1. Provide information to support the development, application, and commercialization of cool storage technology that is competitive with non-storage equipment in terms of efficiency and cost.

Actual Outcomes:

1. Information to support development, application, and commercialization of cool storage technology.
 - A white paper was published that presented an analysis of the impacts of flexible and real-time price scenarios on the design of thermal energy storage systems.
 - Initial results were published of a field demonstration of a Near Optimal Cool Storage Controller at FirstUnion Stadium in Philadelphia. These results can be used to analyze the viability of thermal storage for specific California sites.
 - An analysis was published of a capacity enhancement approach for chilled water thermal energy storage systems.

Status:

The Commission's participation in this target ended as of December 31, 1999.

Target 11 Commercial Building Lighting**Contract #:** 100-98-001 #1**Contractor and Major Subcontractors:** EPRI; University of Wisconsin; Polytechnic University of New York; Los Alamos National Laboratory; National Institute of Standards and Technology; Lighting Research Center; BKL, Inc.; New Buildings Institute; Pacific Consulting Services; Osram-Sylvania, Inc.; Lighting Ideas, Inc.; Gough & Associates, Inc.; National Council on Quantification for Lighting Professionals; Illumination Engineering Society of North America**CEC Project Amount:** 1999: \$ 24,000**Match Funding:** 1999: \$204,323**Contractor Project Manager:** John Kesselring 650/855-2902**Commission Project Manager:** Gary Flamm 916/654-2817**Commission Contract Manager:** Gary Klein 916/653-8555

Project Description: The purpose of this project is to guide California ratepayers to new lighting systems that reduce their energy bills and boost worker productivity and comfort. EPRI's Lighting Information Office (LIO) provides world-class, up-to-date information on lighting technologies and cost-effective training and information services. LIO insights are captured in customer-friendly formats that the Energy Commission can easily customize for delivery to California ratepayers. EPRI has produced an array of system design and analysis software that Commission staff can use in calculating the performance, costs, and benefits of lighting options for any customer's application. In addition, EPRI via this Target is directing collaborative research to define the relationship between lighting and productivity.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by increasing the efficacy of lighting sources with advanced light source technology.

Proposed Outcomes:

1. Provide advanced lighting technologies information.
2. Provide analytical tools to assess advanced lighting technology options.
3. Advance the understanding of lighting benefits and accelerate the development of advanced, high-efficiency lighting products.

Actual Outcomes:

1. Technology information.
 - New information was provided through the Lighting Information Office on energy-efficient lighting—including residential compact fluorescent lighting, electronic ballasts, LED exit signs, and outdoor luminaries. This information can be used to upgrade lighting in all California

state office buildings and to consider for new standards legislation.

- Two training sessions were offered that addressed the unique design, cost, and customer applications issues posed by new advanced lighting products.
2. Analytical tools.
 - The Commercial Desk Book software package was provided. This package provides technical, marketing, and regulatory information on lighting systems and allows users to calculate and compare annual operating costs of different technologies.
 - Software support was provided for LightPAD (the EPRI lighting audit software), PowerDOE, Daylight Analyzer, and other products.
 3. Understanding of lighting benefits, and development of advanced, high-efficiency lighting products.
 - A report described the effects of three different lighting configurations on office workers doing data entry tasks.
 - A publication was provided that reported on significant advances in scotopic vision. Information on the impacts of lighting on human performance can be used to ascertain whether proper light levels are being implemented in office work, and to help ensure that reduced lighting levels do not compromise human performance.
 - Research briefs were presented on basic research related to Hg-Ar and Ba as discharge light sources, which could double the energy efficiency of today's fluorescent lamps.

Status:

The Commission's participation in this target ended as of December 31, 1999.

Commercial Cooling and Heating Pump Applications (#1417)**Contract #:** 100-98-003 (#5)**Contractor and Major Subcontractors:** Gas Technology Institute (GTI), Hybrid Gas Engine/Electric Motor/Chiller – Alturdyne (San Diego, California), Advanced Absorption Cooling – CoolTec, Gas Turbine Inlet Cooling – Polar Works, Commercial Heat Pump – Goettl, Spray Absorption Technology – GTI Performing Laboratories**Contract Amount:** 1999: \$45,600

2000: \$31,500

Contractor Project Manager: Ron Edelstein (847) 768-0898**Commission Contract Manager:** Brad Meister (916) 654-4739

Project Description: The purpose of this project is to develop and deploy cost-effective cooling products and maximize their market adoption and use. Major activities under this project include:

- a) improved chiller performance;

- b) updated state-of-the-art technologies for existing absorption chillers;
- c) low-cost, engine-driven heat pump technologies for commercial applications;
- d) hybrid chiller design protocols; and
- e) research results of advanced turbine component tests.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California’s electricity by providing cooling technologies that will reduce electricity consumption by California energy consumers.

Proposed Outcomes:

- 1. Hybrid Gas Engine/Electric Motor/Chiller:** Development of a Hybrid Gas Engine/Electric Motor/Chiller capable of being run on either natural gas or electricity offering the customer the option of selecting their energy source. The second phase of the project will include reversing the motor to add generation capacity to the chiller for further electricity peak shaving flexibility.
- 2. Advanced Absorption Cooling:** Develop and test a five-ton absorption-based natural gas cooling technology capable of reducing electricity demand by 5-kW per household, or commercial application.
- 3. Gas Turbine Inlet Cooling:** Novel approach to using natural gas cooling to cool the inlet air to gas turbines, increasing the available power output during hot weather. The technology envisioned will allow inlet air temperature to be dropped far lower than with conventional systems without causing turbine damage and therefore will produce significantly greater power from an existing turbine set than available with any other system. The overall effect is an increase in efficiency and a reduction in the capital cost of a turbine generating system.
- 4. Commercial Heat Pump:** Development of a 15-30 refrigeration tons (RT) natural gas engine-driven heat pump with Goettl Air Conditioning.

- 5. Spray Absorption Technology:** Development of technical data on spray distribution of solution for absorption chillers to ascertain technical feasibility.

Actual Outcomes:

- 1. Hybrid Gas Engine/Electric Motor/Chiller:** The initial Hybrid Engine/Electric/Chiller product is now commercially available. The prototype 100-ton unit has been built with the motor to add generation capacity to the chiller for further peak shaving flexibility.
- 2. Advanced Absorption Cooling:** Two laboratory prototypes were built and durability tested in the lab. Testing of one prototype in a certified test chamber has now been completed. The first test unit has been shipped to Brooklyn Union (now Keyspan Energy) for testing this summer.
- 3. Gas Turbine Inlet Cooling:** The initial desiccant dehumidification alpha test was successfully completed. Discussions were conducted with a major turbine manufacturer. However, the manufacturer did not decide to pursue the Polar Works approach due to the results of the modeling effort. This work has now been wrapped up and this contract is being closed out.
- 4. Commercial Heat Pump:** The development of 15, 20, 25, and 30 RT units has been completed, and those units are now commercially available.
- 5. Spray Absorption Technology:** The project has been completed, and results presented to Trane. After testing the concept, Trane decided not to move forward with this concept.

Project Status:

Efforts continue as planned for the Hybrid Gas Engine/Electric Motor/Chiller and Advanced Absorption Cooling projects. The Commercial Heat Pump project was successfully completed. Technical efforts were completed on the Gas Turbine Inlet Cooling and Spray Absorption Technology projects, but work has now been discontinued because manufacturers decided not to pursue the technologies.



**Projects Funded through the
Industrial/Agricultural/Water
End-Use Energy Efficiency
PIER Program Area**

- Projects Funded in 2002
- Projects In Progress
- Projects Completed



Energy Efficient Data Centers

Contract #: 500-01-024

Contractor: Lawrence Berkeley National Laboratory

Subcontractors: Rumsey Engineers, Inc.

Contract amount: \$500,000

Match amount: \$100,000

Contractor Project Manager: William Tschudi

(510) 495-2417

Commission Contract Manager: Paul Roggensack

(916) 654-6560

Project Description: The purpose of this project is to benchmark energy end use and to develop a road map to guide research that will increase energy efficiency at data centers. Data centers are prevalent in many buildings and are an important part of the California economy. These facilities use a large amount of energy. Rapid expansion of information technology and improvements has created a unique challenge to California's power grid.

Data centers are becoming more energy intensive in smaller spaces. Computer power is increasing dramatically while system components shrink. An example of the increased demand for energy use in data centers is the development of the World Wide Web. New Internet "server hotels" are being proposed across California and the nation. Unfortunately, energy efficiency has not evolved as rapidly as component size reduction and other technological improvements.

In addition to increased energy demand from data centers, there is discrepancy between projected electrical demand by developers and building owners and actual electrical consumption. This leads to inefficient operation because there is a tendency to overstate the electrical load of these facilities and their impact on regional power grids. Outdated cooling practices also lead to inefficient operation.

Phase 1 of this project will provide an energy end use breakdown from representative data center facilities. This will result in development of standards and measurements to determine energy efficiency of data centers. The result will be a design guide to enable building planners use a systems approach to design energy efficient data centers.

Phase 2 of this project will develop a road map to guide research and market transformation of new technologies for data centers. LBNL will work with industry experts through workshops and surveys to obtain the necessary information to develop the road map. The road map will provide continuous improvement in energy performance and address opportunities for both retrofit and new construction for data center facilities.

This project contributes to the PIER program objectives of:

- Improving energy cost/value by developing a road map to guide research that will increase energy efficiency at data centers; and
- Improving electricity reliability, quality, and sufficiency by providing data on potential energy savings in a design guide for building planners that can lead to more efficient operations of data centers as they continue to expand across California and the world.

Expected Outcomes:

- Six benchmark studies that categorize energy end use at data centers and will provide a guide for designers and builders of data centers.
- A road map to guide research and market transformation for future technologies at data centers.

Project Status:

LBNL has completed benchmarking studies at two data center facilities and will complete six projects in total. One industry workshop has been held and a draft road map has been completed.

Dynamic Characterization of Process Power Quality

Contract #: 500-01-025 **Project #:** 3

Contractor: Electricity Innovation Institute

Project amount: \$43,036

Contractor Project Manager: Ashok Sundaram

(650) 855-2304

Commission Contract Manager: Pramod Kulkarni

(916) 654-4637

Project Description: The purpose of this project is to analyze the power quality impacts and short and long-term solutions for the California food processing industry using the Del Monte Foods Company plant in Modesto as a benchmark. This effort is intended to lead to a comprehensive power quality supply chain management procedure for the California food processing industry. As part of this supply chain management procedure, a power quality immunity specification will be developed for process automation tools and components in cooperation with representatives of the food processing industry, EPRI, CEC, equipment suppliers, and Standards organizations. In addition, this work will lead to a recommended practice document for addressing power quality issues in food processing industry for existing plant equipment.

The project involves the following tasks:

- Assess the impacts of power quality disturbances on process

automation equipment for the Del Monte Foods plant in Modesto. The project team will complete a baseline assessment for the plant to evaluate the process control tool and equipment requirement and its interaction with the plant electrical environment.

- Develop target ranges for process equipment immunity based on controlled testing. The project team will evaluate the component level sensitivity for the Del Monte Foods plant based on the baseline characterization.
- Develop a final report and technology transfer activities. The project team will develop a comprehensive report specifically for the Modesto plant to describe the short-term and long-term solutions for minimizing power quality related process upsets. A separate report will be developed for distribution to the California food processing industry to describe power quality related impacts and possible short and long-term solutions. EPRI will provide technical support for a final meeting to describe the project results and to provide a framework for starting a comprehensive initiative to develop a PQ immunity standard for food processing industry.

This project supports the PIER program objectives of:

- Improving the reliability/quality of California’s electricity by developing knowledge and procedures to solve power quality problems that cause equipment failures and process disruptions; and
- Improving the energy cost/value of California’s electricity by reducing process inefficiency associated with power quality disturbances.

Proposed Outcomes:

- Reduce the impact of power quality disturbances on the food processing industry by 40 percent.
- Increase the expected number of new technologies providing increased reliability/quality choices to consumers by an order of magnitude.
- Increase the application of automated process controls in the food processing industry by 20 percent.
- Reduce process inefficiency due to power quality and reliability by 20 percent.

Project Status:

The project team performed a site audit at the Modesto Del Monte plant. The findings and recommendations are summarized in a report that will be published in January 2003. The team is in the process of determining the next steps to take in order to transfer this effort to the entire industry.

The EPRI PEAC and Commission staff visited the Del Monte Modesto facility four times during the course of this project as outlined below:

- Site Visit 1: (April 23, 2003) Initiative Introduction. Presentation entitled, “Food Industry PQ Initiative: An Application-Oriented R&D Program,” was given by Dr. Arshad Mansoor. This presentation introduced the program to Del Monte and gave an overview of common power quality problems and solutions. Furthermore, the need for an industry effort and possible power quality standard for the food processing industry were addressed.
- Site Visit 2: (May 22-23, 2002) Initial Site Audit. Brian Fortenbery conducted an initial audit of the Modesto facility. In this audit EPRI PEAC gained an understanding of the Del Monte process at Modesto, including the most critical process areas. A survey of electrical control equipment used was also conducted in order to compare against the EPRI database of known power quality responses.
- Site Visit 3: (August 15, 2002) Technical Training for Del Monte. Mark Stephens and Brian Fortenbery conducted a Power Quality Training and Tech Transfer for Del Monte. EPRI PEAC’s initial analysis of the facility was presented as well as typical power quality problems and solutions for making process systems more robust. This visit also included a walkthrough of the process facilities.
- Site Visit 4: (September 12, 2002) Project Review Meeting. Mark Stephens and Brian Fortenbery conducted this meeting that included 20 stakeholders as attendees. The purpose of the meeting was to review the vision for the initiative, the basic findings of the power quality audit at Del Monte’s Modesto plant, examine known solutions, and review other industry standards efforts that are in place.

Development of an Ultracapacitor-Based Stabilizing System for Generators in Industrial and Commercial Facilities

Contract #: 500-01-025 **Project #:** 4

Contractor: Electricity Innovation Institute

Project amount: \$310,384

Contractor Project Manager: Ashok Sundaram
(650) 855-2304

Commission Contract Manager: Pramod Kulkarni
(916) 654-4637

Project Description: The purpose of this project is to develop a dynamic stabilizer that will improve the performance and reduce the cost of both grid-connected and off-grid generator systems. This device will have the potential to significantly enhance the performance of California’s industrial and commercial customer generator installations.

Many California industrial and commercial facilities have installed on-site generators to improve the reliability of power

to critical loads. However, when these generators operate off the grid, they may have difficulty with motor starting or other load changes. This can have a significant impact on sensitive loads in the system. Generators used in off-grid applications are often oversized by as much as a factor of two in order to handle the transient load steps that occur. This oversizing wastes capital expense and also means the engines are operating less efficiently because they are underloaded. These factors increase the cost of industrial and commercial generators that must load follow—usually off-grid applications.

The dynamic stabilizer will provide bridging power and voltage stabilization so that step load changes can be accommodated without oversizing the generator. By providing this load following capability, the dynamic stabilizer will reduce the costs of distributed generation, improve power quality, and increase industrial and commercial productivity.

This project supports the PIER program objectives of:

- Improving the reliability/quality of California’s electricity by developing a new technology that will enhance the value and performance of distributed generation;
- Improving the energy cost/value of California’s electricity by allowing smaller, more efficient generators to be used for a given application, resulting in lower capital costs and lower operating costs; and
- Improving the environmental and public health costs/risk of California’s electricity by reducing environmental emissions associated with distributed generation by enabling more efficient generators to be used for a given application.

Proposed Outcomes:

- Reduce distributed generator capital expenses. By leveraging California’s distributed generation (DG) systems to serve larger loads, the cost of DG applications in the state can be lowered by as much as 25 percent.
- Improve generator-operating efficiency. Reduced fuel consumption and increased efficiency of generators will result in reduced operating costs and reduced environmental emissions. The potential exists to reduce fuel usage in some applications by as much as 20 percent.
- Improve generator power quality, which will contribute directly to improved productivity and profitability of California industries.
- Accelerate the growing California market in off-grid generator applications and increase the feasibility of a wide range of utility and/or customer operated DG applications where intentional islanding is performed.
- Economically benefit on-grid DG applications. The dynamic stabilizer will mitigate some of the distribution system impacts.

Project Status:

In 2002 the project team began the review of existing products such as fuel cells, microturbines and conventional rotating generators to determine their needs for stabilization, and compare with EPRI PEAC’s extensive database of load characteristics (both starting and steady-state running requirements).

In 2003 the project will:

- Determine the functional specifications for the dynamic stabilizer, including its voltage rating, power requirements, energy storage needs, response characteristics, modes of operation, packaging requirements, thermal design, etc.
- Identify the prototype hardware requirements based on the functional specifications. This includes identifying the vendors of off-the-shelf components that can be used in the system, as well as any special hardware development needs or modifications to off-the-shelf equipment that are required. Examples of elements identified in this task include the power electronics, energy storage, packaging, software and hardware controllers, filters, transformers (if any), protection and other components.
- Develop a detailed *system* design that includes the functional specifications, detailed system diagrams, and parts lists/vendor suppliers. The design is presented in a preliminary design document and is the working design for the first prototype.
- Begin development of the first prototype.

Upon completion of prototype development, a series of tests will be performed at EPRI PEAC’s distributed generation test facility to evaluate the prototype’s performance in stabilizing generators during both steady state and transient loading conditions. The project team will also prepare a technology transfer plan to make the knowledge gained in the project available to decision-makers in industry and government.

Methodology to Optimize Compressed Air Energy Storage (CAES) for Industry

Contract #: 500-01-026

Contractor: Southern California Edison

Contract amount: \$178,000

Contractor Project Manager: Babu Joseph
(626) 633-7177

Commission Contract Manager: Rajesh Kapoor
(916) 654-4611

Project Description:

The purpose of this project is to develop a benchmark (reference point) and the methodology to quantify the central

plant efficiency of compressed air systems. Compressed air is the fourth largest commonly used utility in the industrial operation after the electricity, natural gas and water. At present, the efficiency of an individual air compressor unit is well established and has a recognized benchmark. However, the entire compressed air system in a plant has no benchmark for the quantified efficiency. The lack of this benchmark has made it difficult to develop an optimum operating strategy and has inhibited energy efficiency improvements.

There are numerous California industries that use the compressed air as the plant energy source. There are methods available in the industry to control the efficiency of the compressor but there are no methods available, at the present time, to optimize the efficiency of the compressed air system in a central plant. In most plants, there are many opportunities for the energy conservation related to the generation, distribution and use of the compressed air. An estimated 30 percent of the total energy cost of the central plant is from the compressed air energy system. In some industries, the waste of energy associated with the compressed air system is as high as 40 percent. Consequently, the penalty for the improper management of the compressed air energy system is very high and there is a need for the methodology to quantify the central plant efficiency of the compressed air system.

This project contributes to the PIER program objective of:

- Improving the energy cost/value of California's electricity by helping create the methodology to quantify efficiency of CAES systems in a central plant.

This project is also supported by the Emerging Technology Coordination Council (ETTC), Pacific Gas & Electric, San Diego Gas & Electric and a group organized under California Public Utilities Commission (CPUC) directive. The contractor will make available the findings and the reports with all the utilities and their industrial customers.

Expected Outcomes:

- Establish the benchmark and develop the methodology to quantify the central plant efficiency of the compressed air systems.
- Assist the California utilities to provide an acceptable process for energy efficiency rebate programs.
- Provide the industrial customer an acceptable procedure to assess his system performance and evaluate his system against others.
- Disseminate information generated by this project to industry stakeholders by means of papers, presentations, workshops, etc.

Project Status:

- The kick-off meeting was held at the California Energy Commission on July 31, 2002.
- The project start-up industrial meeting was held at SCE office on September 5, 2002. Participants at this meeting identified the applicable metering devices for the flow measurement, identified the customer sites that were good candidates for the instrumentation and testing, and selected six sites for the testing.
- The contractor has purchased all the measurement devices for the testing. The flow, static pressure and temperature devices have been calibrated. The planning is to finish the testing at the site number 1 in the month of January 2003.
- The project is one month delayed due to the contractor not receiving the measurement devices in the month of December 2002.
- The project is within budget and is expected to achieve its goals.

Gas Fired Hot Water Heat Pump Thermosorber for Food and Beverage Industry

Contract #: 500-01-028

Contractor: Energy Concepts Company

Subcontractors: NOVA Greening

Contract amount: \$240,000

Contractor Project Manager: Donald Erickson
(410) 266-6521

Commission Contract Manager: Rajesh Kapoor
(916) 654-4611

Project Description:

The purpose of this project is to demonstrate a Gas-fired Hot Water Heat Pump Thermosorber in the food and the beverage industries. The proposed technology approximately doubles the energy efficiency by co-producing the hot water and the chilling concurrently. This technology is projected to reduce the consumption of the natural gas by 40 percent in the hot water production, and reduce the chilling production cost by as much as 80 percent. The economic payback of reducing the gas and electric utility costs is less than two years. Even at this early commercialization stage, the technology has a high market potential.

Many food and beverage industries require heating and cooling processes and storage applications. Gas-fired boilers supply the heat while electrically driven refrigeration systems provide the cooling. The cost of the energy consumed by these devices is a major concern of the industry. Gas-fired, hot water heat pump Thermosorbers transfer the heat from the lower temperature to a higher temperature. In effect, thermosorbers produce both

the cooling and the heating concurrently using a fraction of the total energy. The industry, however, is not familiar with this technology. The results of this project will be made available to the Food and Beverage Industry as a means of lowering operating costs.

This project contributes to the PIER program objective of:

- Improving the energy/cost value of California's electricity by significantly reducing the use of natural gas used to heat water and the production cost of chilling used in the Food and Beverage Industry in California.

Expected Outcomes:

- Reduce the consumption of the natural gas by 40 percent in the hot water production along with 80 percent reduction in electric use by co-producing chilling.
- Demonstrate a high-efficiency, gas-fired hot water heat pump Thermosorbers technology, which transfers the heat from a lower temperature to a higher temperature, and produces the cooling and heating at the same time using a fraction of total energy.

Project Status:

- The kick-off meeting was held at the California Energy Commission on May 6, 2002. The goal is to install the two thermosorber units at the two field demonstration sites and prepare the performance test report.
- The contractor has defined the application requirements at one of the two field demonstration sites, identified the design and installation constraints, and prepared a draft test plan that defines the testing procedure and methods of monitoring the performance of the Thermosorber unit first at the contractor's site and then at the field demonstration site.
- The second field demonstration selected was Butterfield Brewery in Fresno, CA. This brewery is undergoing a relocation and many other changes. Therefore, the contractor will select an alternate field demonstration site before February 28, 2003 and will prepare the draft test plan for the installation of the second thermosorber by April 2003.
- The first thermosorber unit will be installed in the first demonstration site in the second week of February 2003.
- The project is three months delayed due to the change in the second field demonstration site.
- The project is within budget and is expected to achieve its goals.

Water and Wastewater Energy Efficiency Road Map

Contract #: 500-01-040

Contractor: American Water Works Association Research Foundation

Contract amount: \$400,000

Match amount: \$400,000

Contractor Project Manager: Linda Reekie (303) 734-3423

Commission Contract Manager: Paul Roggensack (916) 654-6560

Project Description: The purpose of this project is to research ways to help improve the energy efficiency of the way water is used for consumption and treatment. The availability of clean water at a low cost is essential to California's economy and continued prosperity. California needs to treat large quantities of water to meet both municipal and waste discharge requirements. These activities are heavily dependent on electricity. Water treatment facilities in California use 4 percent of all the electricity used in California.

The PIER IAW program will focus on RD&D activities that help improve the energy efficiency of water for urban, industrial and agricultural consumption and efficient treatment of wastewater. The American Water Works Association (AwwaRF) sponsors research to help water utilities provide high-quality water, an efficient and customer-responsive organization, infrastructure reliability, and environmental leadership. Success with AwwaRF on the Technology Road Map could lead to future collaborative efforts.

This project contributes to the PIER program objectives of:

- Improving the energy cost/value of California's electricity by helping water utilities improve the efficiency of their use of water consumption and treatment;
- Improving the environmental and public health costs/risk of California's electricity by using less energy to provide and treat water; and
- Improving the safety of California's electricity helping provide low-cost clean water.

Expected Outcomes:

- Develop a Technology Road Map for Water and Wastewater Treatment Technologies. The purpose of the Technology Road map will be to identify and prioritize research opportunities aimed at energy efficiency, cost and reliability affecting water and wastewater utilities.
- Fund up to three projects identified as the highest priorities from the Technology Road map.

Project Status:

The workshop to develop the Technology Road Map has been scheduled for late February of 2003. Release of a Request for Proposals to implement the Technology Road Map is tentatively scheduled for the spring of 2003.

Electrodialysis Systems for Tartrate Stabilization of Wine

Contract #: 500-02-009

Contractor: Winesecrets Inc.

Subcontractors: Ameridia, Innovation, Inc

Contract amount: \$309,757

Match amount: \$926,229

Contractor Project Manager: Eric Dahlberg (707) 738-5083

Commission Contract Manager: Pramod Kulkarni (916) 654-4637

Project Description: The purpose of this project is to demonstrate the tartrate stabilization process for wine industry using electrodialysis. This technology requires less than 20 percent of the electrical energy used in the conventional cold stabilization process. Adoption of this process will enable the California wine industry to improve wine marketability and quality while reducing bottle price.

Tartrates of potassium and calcium occur naturally in grapes at near-saturation levels. These salts precipitate in wine during storage and reduce the market appeal of wines. Tartrate stabilization is commonly used in the wine industry to reduce the concentration of these salts to safer levels to prevent precipitation. Cold storage is the method used predominately in the United States for this purpose. The total electrical energy consumption for cold stabilization is estimated at about 70kWh per thousand gallons of wine.

Electrodialysis is an electrically driven membrane process that separates ionized solutions from aqueous solutions. It is widely used for desalination of seawater, demineralization of whey and many other applications. Recent advances in membrane development have enabled application of this technology for tartrate to stabilization of wines. Electrodialysis uses about 12 kWh per thousand gallons of wine, which makes it less energy intensive than cold stabilization. It may also produce better quality wines. Lacking proof that the new technology will not affect the permitting and color, taste or smell of its product, however, the wine industry in California has not installed this promising technology. This demonstration will possibly help overcome this barrier.

This project contributes to the PIER program objective of:

- Improving the cost/value for the industrial electric ratepayers in California by improving the marketability of the product while reducing the price.

Expected Outcomes:

- Demonstration of mobile electrodialysis systems in three California wineries
- Report of the performance and electricity savings
- Installation of one stationary electrodialysis system in California
- Acceptance of this technology by the Bureau of Alcohol, Tobacco & Firearms (BATF)
- A technology transfer workshop

Project Status:

- Completed the kick-off meeting in Dec 20, 2002
- The mobile unit has been ordered.
- The first demonstration at a winery is expected to begin in February 03.



Metropolitan Water District of Southern California

Contract #: 400-00-013

Contractor: Metropolitan Water District of Southern California

Contract amount: \$2,000,000

Match amount: \$3,013,688

Contractor Project Manager: Sun Liang (909) 392-5273

Commission Contract Manager: Shahid Chaudry
(916) 544-4858

Project Description: The purpose of this contract is to co-fund the full-scale demonstration and refinement of newly developed electro-technologies for producing potable and non-potable water. These technologies remove salinity and disinfect various source waters (i.e., Colorado River water, brackish ground water, municipal wastewater, and agricultural drainage water). The Energy Commission partially funded development of these technologies through PIER Transition Funding (\$410,000- 1997) and PIER I Funding (\$1,200,000- 1998).

This project supports the PIER Program objectives of:

- Improving electricity reliability/quality/sufficiency of California's electrical system by providing energy savings of approximately 12 GWh in avoided water transport and production of high quality potable water;
- Improving the energy cost/value of California's electricity by producing an additional 7,000,000 acre feet of water with savings of approximately \$140,000,000 from developing local water supplies instead of importing water from outside the region, reducing pumping costs and energy usage; and
- Improving the environment, public health and safety by avoiding approximately \$500,000,000 of salinity damages.

Expected Outcomes:

- Demonstrate new and large-scale electro-technologies that reduce the energy requirement and cost of producing potable water
- Partner with industry to ensure the commercial implementation of newly developed treatment technologies
- Reduce the need for energy-intensive water imports through technologies allowing development of local, non-traditional water supplies

The project is expected to provided the following benefits to the State of California:

- Electric utility ratepayers would benefit from reduced energy used to transport and produce high quality potable water in the region. Total energy savings are estimated to be 12,000 gigawatt-hours (GWh) over 20 years,

- Additional development of local water supplies could partially offset the need to import water from outside the region, reducing pumping costs and energy usage. The results generated from this study may result in 7,000,000 acre-feet of additional potable water for California,
- Savings from developing local supplies are estimated to be in excess of \$140 million, and
- Savings from avoiding salinity damages to commercial, industrial, and residential property are estimated to be in excess of \$500 million.

Project Status:

The original term of this contract was from January 15, 2001 to July 31, 2003. A no-cost time-extension has extended the term of this contract to March 31, 2005. Also, the work scopes under subtasks 2.2.3 and 2.3.2 have been changed. New work under subtask 2.2.2 will expand its scope to include the rejection pattern of wastewater derived micro-pollutants in high-pressure membrane applications. Under subtask 2.3.2, the subcontractor will develop a knowledge base of existing low-pressure membrane filtration (Reverse Osmosis and Nano-Filtration) plants worldwide that treat five types of water and wastewater.

The start of this project was delayed by six months from the original proposed start date due to the legal and contractual issues between the Commission and MWD. Execution of subcontracts agreements preceded slower than initially anticipated due to contract language issues between the contractor and subcontractors. Currently, all but two of the sub-agreements have been executed. Of the executed agreements, several of the test plans have been prepared. Work on the remaining test plans is well underway or is substantially completed. Research apparatus preparation has begun on several of the tasks. Overall, approximately 25 percent of the work on this contract has been completed.

Energy Efficiency Measures for High Tech Buildings, Clean Rooms and Laboratories

Contract #: 400-00-020

Contractor: Lawrence Berkeley National Laboratory

Subcontractors: Northwest Energy Efficiency Alliance, U.S. DOE, ASHRAE, SEMATECH, Major Energy Users Group (MEUG), Northwest Energy Efficiency Alliance (NEEA), EPA/FEMP Laboratories for the 21st Century, University of California, California State University System.

Contract amount: \$652,000

Match amount: \$125,000

Contractor Project Manager: John Kesselring
(650) 855-2902

Commission Contract Manager: Tony Wong (916) 654-4015

Project Description: The purpose of this project is to research and develop design tools and a guidebook for energy efficient cleanrooms for high-tech industries and laboratories. Laboratories and cleanrooms serve the semiconductor, electronics, bio-pharmaceutical sectors. In addition, the contract will evaluate and support field demonstrations and tests of the low-flow fume hood.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity to electric ratepayers by reducing energy use or improving energy efficiency in the industrial sector.

Proposed outcomes:

- Develop a cleanroom facility planning guide that provides guidance to cleanroom owners and designers in setting and implementing an energy strategy in the programming process, prior to detailed design.
- Evaluate field performance of a low-flow fume hood and identify design improvements.
- Complete development of a laboratory design intent tool that will allow laboratory designers to effectively document their approach and expectations related to energy performance and design throughout the life of the facility.
- Develop a more comprehensive road map that will identify additional research needs, needed energy technologies for high-tech buildings, energy systems with the most potential for energy savings.

Project Status:

The Cleanroom Programming Guide was completed (LBNL report number 49223) and issued for trial use in December 2001. Copies of laboratory design intent tool were distributed to attendees at the "Laboratories for the 21st Century" conference in October 2002. A case study was completed for a proposed laboratory facility at UC Merced. High priority research tasks as identified by the road map process and subsequent survey of industry participants were presented at the Silicon Valley Manufacturers Group meeting in May 2002. A technology road map for High-performance Laboratories and Cleanrooms was completed (LBNL report number 50599). A final report has been prepared for the above three tasks.

The development and demonstration of the six-foot Berkeley hood has encountered some problems. First, the delivery of the prototype was delayed from the manufacturer and required extensive corrective re-construction. Second, the process for obtaining a variance from Cal/OSHA for field demonstration has taken more time than anticipated. Currently, LBNL staff are

working with Cal/OSHA Standards Board staff to seek an interpretation from the American National Standards Institute regarding an equivalent performance indicator for "traditional" face velocity. This interpretation would be used to evaluate laboratory-type hoods having design features that do not use traditional face velocity as their method of containment.

Energy Efficient Agricultural Technologies

Contract #: 400-99-005

Contractor: Regents - Davis

Contract amount: \$1,793,000

Contractor Project Manager: James Thompson
(423) 470-9222

Commission Contract Manager: Ricardo Amon
(916) 654-4019

Project Description: The purpose of this contract is to advance the development of energy efficient agricultural technologies. The contract funds research, development and demonstration projects that use of ozone as a substitute soil fumigant to replace chemical pesticides ozone as an alternative to aqueous toxic chemicals for fungi control in fruit packing plants irrigation scheduling systems precision farming technologies and innovative manure treatment technologies.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by increasing the efficiency of emerging electro-technology applications in agriculture
- Improving the environmental and public health costs/risks of California's electricity by replacing toxic chemicals used in agribusiness with cleaner electro-technologies

Expected Outcomes:

- New protocols for the most energy efficient methods to control dairy manure lagoon systems to optimize performance and reduce pollution emissions.
- New tool to optimize field tillage equipment to meet soil type conditions to improve soil water infiltration rates, thus reducing watering requirements
- New protocols for the most energy efficient use of ozone technologies to disinfect fruit and vegetables in the cleaning, packing and storage of fresh produce.
- New recommendations to determine when and how much water to apply in tree and vine crops utilizing deficit irrigation principles.

Project Status:

- The soil ozone project has completed the field research phase and issued a final report. Although the technology is

effective at controlling soil borne diseases and pests, further field adoption demonstrations are needed to further promote the practice among farmers.

- The project using ozone to control fungi in cold water wash process at packing sheds has finalized the research phase and continues to disseminate information to companies considering the upgrade of their systems to incorporate the technology.
- The project using ozone to control invertebrate pests has proven the concept to be ineffective at reasonable ozone levels. Further research is underway to mix ozone with CO₂ gas to further improve control.
- The dairy manure waste management project has had delays due to uncooperative farms not committed to following the research methods, thus rendering field data unsuitable. A new cooperator, however, is available for the 2003 season with the commitment to follow the researcher's protocol. By the end of the year the researchers expect to have a best management practices recommendation to the dairy industry.
- The two precision agriculture projects have completed the research phase by building second generation prototype tools. During the 2003 growing season, the projects will conduct further field tests to complete data gathering and evaluation.
- The deficit irrigation project has concluded the field research activities. Research results were inconclusive regarding the accuracy of the data provided by the trunk moisture measurement device. Further research is needed to calibrate the tool. The project researcher has communicated with the equipment manufacturer providing recommendations for further product improvements.

PIER Agriculture Energy End Use Efficiency

Contract #: 400-99-014

Contractor: California Poly University Foundation

Contract amount: \$1,500,000

Contractor Project Manager: Charles Burt (805) 756-2379

Commission Contract Manager: Ricardo Amon
(916) 654-4019

Project Description: The purpose of this contract is to improve the energy efficiency in the transportation, delivery, and utilization of agricultural water provided by irrigation districts. Until the infrastructure of the irrigation districts are adequately addressed, most sophisticated on-farm irrigation technologies such as precise irrigation scheduling, fertigation, and automated irrigation systems will not be widely adopted by farmers. This project will research and help develop and implement certain technologies to improve water-use efficiency.

Power quality, which is a related issue, will also be researched in so far as it impacts the irrigation districts.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by increasing the efficiency of emerging electro-technology applications in agriculture; and
- Improving the environmental and public health costs/risks of California's electricity by replacing toxic chemicals used in agribusiness with cleaner electro-technologies

Expected Outcomes:

- Document the implementation of new technologies;
- Develop a simple procedure for tuning controller constants for automatic upstream control of canal check structures;
- Develop new devices for volumetric metering of delivered water - trash shedding propeller meters resistant to plugging or tangling moss;
- Test and evaluate new electronic technologies for volumetric metering of delivered water such as Magnetic Meters, Ultrasonic Meters (Doppler), Vortex Shedding Meters and Ultrasonic Flow-Measurement Meters; and
- Develop strategies for energy-efficient transition from low pressure non-reinforced concrete pipe
- Verify power quality measurement and conditioning methods.

Project Status:

- New Technology Implementation at California Irrigation Districts project: Researchers published an Infrared Technology for Preventative Maintenance fact sheet and mailed the fact sheet to districts throughout California. The project also documented benefits for variable frequency drive/SCADA applications and developed guidelines for ensuring a proper variable frequency drive installation on an existing pump.
- New Electronic Technologies for Volumetric Metering of Delivered Water – Magnetic, Doppler, Vortex Shedding and Ultrasonic Flow Measurement project: The first season of field-testing for ultrasonic and magnetic flow meters began at Patterson Irrigation District (PID). A comprehensive field testing report has been prepared that summarizes the design, installation and operation of the McCrometer Ultra Mag, Mace AgriFlo, and Unidata Starflow meters installed at three farm turnouts in PID.
- Development of Strategies for Energy-Efficient Transition from Low Pressure Non-Reinforced Concrete Pipe project: Researchers presented a paper at the USCID/ ASCE meeting in San Luis Obispo in June, regarding the South San Joaquin Irrigation District project. California Polytechnical University at San Luis Obispo (CalPoly) researchers completed a re-

calibration and update of their main canal gate algorithm, to help ensure reliable deliveries to their new project. Hancor is still in the process of testing its new coupler and lining designs. Calpoly has met with the primary Hancor engineering representative in June, and he now anticipates that the new design will be available in early September. Chowchilla Irrigation District's manager has stated a willingness to cooperate with some field-testing.

- Development of a Simple Procedure for Tuning Controller Constants for Automatic Upstream Control of Canal Check Structures project: ITRC contracted with Concepts in Controls to provide second complete listing of PLC logic, which will be mapped in a continuing effort to provide better specifications for commercial integrators to follow. There is a delayed purchasing of the Dutch simulation program SOBEK until it is capable of simulating composite check structures — those with both underflow and overflow structures in one location. Work continues on simulations in refining the tuning mechanism.
- New Devices for Volumetric Metering of Delivered Water - Trash Shedding Propeller Meters: The first season of field-testing for trash shedding propeller meters began at Patterson Irrigation District (PID). A separate comprehensive field testing report has been prepared that summarizes the design, installation and operation of the advanced flow meters installed at two farm turnouts in PID. The McCrometer reverse propeller meter was installed in PID 3N22. The McCrometer propeller meter was read by the ITRC during a site visit on July 15th. The Sparling propeller meter has been installed in PID 2N36. The Sparling propeller meter was read by the ITRC during a site visit on July 15th. The district operators are periodically checking the flow meter during the season while deliveries are being made.
- Power Quality Measurement and Conditioning project: The project is approximately 95 percent complete. CalPoly met with a number of integrators and variable frequency drive (VFD) manufacturers. The researchers discovered that the existing specifications (IEEE standards) were actually designed for allowable harmonics on the supply side of utility transformers, yet in many cases, the manufacturers of VFDs have been held to those standards—even though the harmonics decline appreciably over the transformer. CalPoly researchers also reviewed the specifications regarding phases and UF disturbance—factors that influence the life of the motor and disturbance to passersby (audible noise or radio interference). After experimenting with various sensors attached to Programmable Logic Controllers exposed to dirty power, the researchers concluded that there is no potential harm to sensor integrity. Based on what is known now, no more field tests will be conducted. Instead, the research will focus on learning more about how to specify the VFD units

themselves to minimize harmonics problems. Because there is no IEEE standard for meaningful VFD controller specifications, CalPoly will closely examine the various manufacturer specifications and develop an appropriate specification list that protects the motor and the line. Following this research, CalPoly will write up a brochure. In the meantime, the knowledge gained has been continually used to upgrade the VFD specifications that ITRC uses to assist districts. This knowledge is also being used in short courses—such as the advanced pump short course scheduled for late August 2002.

Dynamic Characterization of Process Power Quality

Contract #: 500-01-025 **Project #:** 3

Contractor: Electricity Innovation Institute

Project amount: \$22,736

Match amount: \$20,300

Contractor Project Manager: Ashok Sundaram
(650) 855-2304

Commission Contract Manager: Pramod Kulkarni
(916) 654-4637

Project Description: The purpose of this project is to analyze the power quality impacts and short and long-term solutions for the California food processing industry using the Del Monte Foods Company plant in Modesto as a benchmark. This effort is intended to lead to a comprehensive power quality supply chain management procedure for the California food processing industry. As part of this supply-chain management procedure, a power quality immunity specification will be developed for process automation tools and components in cooperation with representatives of the food processing industry, EPRI, CEC, equipment suppliers, and Standards organizations. In addition, this work will lead to a recommended practice document for addressing power quality issues in food processing industry for existing plant equipment.

The project will accomplish the following tasks:

- Assess the impacts of power quality disturbances on process automation equipment for the Del Monte Foods plant in Modesto. The project team will complete a baseline assessment for the plant to evaluate the process control tool and equipment requirement and its interaction with the plant electrical environment.
- Develop target ranges for process equipment immunity based on controlled testing. The project team will evaluate the component level sensitivity for the Del Monte Foods plant based on the baseline characterization.
- Develop a final report and technology transfer activities. The

project team will develop a comprehensive report specifically for the Modesto plant to describe the short-term and long-term solutions for minimizing power quality related process upsets. A separate report will be developed for distribution to the California food processing industry to describe power quality related impacts and possible short and long-term solutions. EPRI will provide technical support for a final meeting to describe the project results and to provide a framework for starting a comprehensive initiative to develop a PQ immunity standard for food processing industry.

This project supports the PIER program objectives of:

- Improving the reliability/quality of California’s electricity by developing knowledge and procedures to solve power quality problems that cause equipment failures and process disruptions; and
- Improving the energy cost/value of California’s electricity by reducing process inefficiency associated with power quality disturbances.

Proposed Outcomes:

- Reduce the impact of power quality disturbances on the food processing industry by 40 percent;
- Increase the expected number of new technologies providing increased reliability/quality choices to consumers by an order of magnitude;
- Increase the application of automated process controls in the food processing industry by 20 percent; and
- Reduce process inefficiency due to power quality and reliability by 20 percent.

Project Status:

The project team performed a site audit at the Modesto Del Monte plant. The findings and recommendations are summarized in a report that will be published in January 2003. The team is in the process of determining the next steps to take in order to transfer this effort to the entire industry.

The EPRI PEAC and Commission staff visited the Del Monte Modesto facility four times during the course of this project as outlined below:

Site Visit 1: (April 23, 2003) Initiative Introduction. Presentation entitled, “Food Industry PQ Initiative: An Application-Oriented R&D Program,” was given by Dr. Arshad Mansoor. This presentation introduced the program to Del Monte and gave an overview of common power quality problems and solutions. Furthermore, the need for an industry effort and possible power quality standard for the food processing industry were addressed.

Site Visit 2: (May 22-23, 2002) Initial Site Audit. Brian Fortenbery conducted an initial audit of the Modesto facility. In this audit EPRI PEAC gained an understanding of the Del Monte process at Modesto, including the most critical process areas. A survey of electrical control equipment used was also conducted in order to compare against the EPRI database of known power quality responses.

Site Visit 3: (August 15, 2002) Technical Training for Del Monte. Mark Stephens and Brian Fortenbery conducted a Power Quality Training and Tech Transfer for Del Monte. EPRI PEAC’s initial analysis of the facility was presented as well as typical power quality problems and solutions for making process systems more robust. This visit also included a walkthrough of the process facilities.

Site Visit 4: (September 12, 2002) Project Review Meeting. Mark Stephens and Brian Fortenbery conducted this meeting that included 20 stakeholders as attendees. The purpose of the meeting was to review the vision for the initiative, the basic findings of the power quality audit at Del Monte’s Modesto plant, examine known solutions, and review other industry standards efforts that are in place.

Development of an Ultracapacitor-Based Stabilizing System for Generators in Industrial and Commercial Facilities

Contract #: 500-01-025 **Project #:** 4

Contractor: Electricity Innovation Institute

Project amount: \$163,977

Match amount: \$146,407

Contractor Project Manager: Ashok Sundaram
(650) 855-2304

Commission Contract Manager: Pramod Kulkarni
(916) 654-4637

Project Description: The purpose of this project is to develop a dynamic stabilizer that will improve the performance and reduce the cost of both grid-connected and off-grid generator systems. This device will have the potential to significantly enhance the performance of California’s industrial and commercial customer generator installations.

Many California industrial and commercial facilities have installed on-site generators to improve the reliability of power to critical loads. However, when these generators operate off the grid, they may have difficulty with motor starting or other load changes. This can have a significant impact on sensitive loads in the system. Generators used in off-grid applications are often oversized by as much as a factor of two in order to handle

the transient load steps that occur. This oversizing wastes capital expense and also means the engines are operating less efficiently because they are underloaded. These factors increase the cost of industrial and commercial generators that must load follow—usually off-grid applications.

The dynamic stabilizer will provide bridging power and voltage stabilization so that step load changes can be accommodated without oversizing the generator. By providing this load following capability, the dynamic stabilizer will reduce the costs of distributed generation, improve power quality, and increase industrial and commercial productivity.

This project supports the PIER program objectives of:

- Improving the reliability/quality of California’s electricity by developing a new technology that will enhance the value and performance of distributed generation;
- Improving the energy cost/value of California’s electricity by allowing smaller, more efficient generators to be used for a given application, resulting in lower capital costs and lower operating costs; and
- Improving the environmental and public health costs/risk of California’s electricity by reducing environmental emissions associated with distributed generation by enabling more efficient generators to be used for a given application.

Proposed Outcomes:

- Reduce distributed generator capital expenses: By leveraging California’s distributed generation systems to serve larger loads, the cost of DG applications in the state can be lowered by as much as 25 percent.
- Improve generator-operating efficiency: Reduced fuel consumption and increased efficiency of generators will result in reduced operating costs and reduced environmental emissions. The potential exists to reduce fuel usage in some applications by as much as 20 percent.
- Economically benefit on-grid DG applications: The dynamic stabilizer will mitigate some of the distribution system impacts.
- Improve generator power quality, which will directly contribute to improved productivity and profitability of California industries.
- Accelerate the growing California market in off-grid generator applications and increase the feasibility of a wide range of utility and/or customer operated DG applications where intentional islanding is performed.

Project Status:

In 2002, the project team began reviewing existing products such as fuel cells, microturbines and conventional rotating generators to determine their needs for stabilization, and how they compared with EPRI PEAC’s extensive database of load

characteristics (both starting and steady-state running requirements).

In 2003 the project will:

- Determine the functional specifications for the dynamic stabilizer, including its voltage rating, power requirements, energy storage needs, response characteristics, modes of operation, packaging requirements, thermal design, etc;
- Identify the prototype hardware requirements based on the functional specifications. This includes identifying the vendors of off-the-shelf components that can be used in the system, as well as any special hardware development needs or modifications to off-the-shelf equipment that are required. Examples of elements identified in this task include the power electronics, energy storage, packaging, software and hardware controllers, filters, transformers (if any), protection and other components;
- Develop a detailed system design that includes the functional specifications, detailed system diagrams, and parts lists/vendor suppliers. The design is presented in a preliminary design document and is the working design for the first prototype; and
- Begin development of the first prototype.

Upon completion of prototype development, a series of tests will be performed at EPRI PEAC’s distributed generation test facility to evaluate the prototype’s performance in stabilizing generators during both steady state and transient loading conditions. The project team will also prepare a technology transfer plan to make the knowledge gained in the project available to decision-makers in industry and government.

Methodology to Optimize Compressed Air Energy Storage (CAES) for Industry

Contract #: 500-01-026

Contractor: Southern California Edison

Contract amount: \$178,000

Contractor Project Manager: Babu Joseph (626) 633-7177

Commission Contract Manager: Rajesh Kapoor (916) 654-4611

Project Description: The purpose of this project is to develop a benchmark (reference point) and the methodology to quantify the central plant efficiency of compressed air systems. Compressed air is the fourth largest commonly used utility in industrial operations after electricity, natural gas and water, and there are numerous California industries that use CAES as the energy source. An estimated 30 percent of the total energy cost of the central plant can come from a compressed air energy system. In some industries, the waste of energy associated with the CAES is as high as 40 percent.

At present, the efficiency of an individual air compressor unit is well established and has a recognized benchmark, however, the entire compressed air system in a plant has no benchmark. The lack of this benchmark has made it difficult to develop an optimum operating strategy and has inhibited energy efficiency improvements for central plant CAES.

This project is also supported by the Emerging Technology Coordination Council (ETTC), Pacific Gas & Electric, San Diego Gas & Electric and a group organized under California Public Utilities Commission (CPUC) directive. SCE will make available the findings and the reports with all the utilities and their industrial customers.

This project contributes to the PIER program objective of:

- Improving the energy cost/value of California's electricity by helping create the methodology to quantify efficiency of CAES systems in a central plant.

Expected Outcomes:

- Establish the benchmark and develop the methodology to quantify the central plant efficiency of the compressed air systems;
- Assist the California utilities to provide an acceptable process for energy efficiency rebate programs;
- Provide the industrial customer an acceptable procedure to assess his system performance and evaluate his system against others; and
- Disseminate information generated by this project to industry stakeholders by means of papers, presentations, workshops, etc.

Project Status:

The kick-off meeting was held at the California Energy Commission on July 31, 2002. The project start-up industrial meeting was held at SCE office on September 5, 2002. Participants at this meeting identified the applicable metering devices for the flow measurement, identified the customer sites that were good candidates for the instrumentation and testing, and selected six sites for the testing. The contractor has purchased all the measurement devices for the testing. The flow, static pressure and temperature devices have been calibrated. The planning is to finish the testing at the site number 1 in the month of January 2003. The project is within budget and is expected to achieve its goals.

Advanced Distillation

Contract #: 100-98-001 **Project #:** 36

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$100,000

Match amount: \$2,500,000

Contractor Project Manager: Ed Fouche (919) 515-7550

Commission Contract Manager: Pramod Kulkarni (916) 654-4637

Project Description: The purpose of this project is to determine more precisely the potential benefits to the state of California of implementing advanced distillation within the state. Advanced distillation technology includes a number of enhancements to a design concept called "distributed distillation," which is an energy optimization analysis that aims to eliminate inefficiencies in conventional distillation. Advanced distillation can typically reduce energy use requirements, cooling water requirements, and environmental emission per pound of distillate by 50 percent. Any industry that uses distillation can potentially benefit from advanced distillation. The two industries that use the most distillation are petroleum refining and the hydrocarbon portion of the chemical industry (which includes industrial organic chemicals, plastics, organic detergents, organic pesticides and agricultural chemicals, and adhesives and sealants).

This project supports the PIER Program objectives of:

- Improving and enhancing the energy cost/value of California's electricity by developing and demonstrating an energy efficient industrial program for the chemical and petroleum industry; and
- Improving the environmental and public health costs/risks of California's electricity by reducing environmental impacts from California's petroleum and chemical industry production processes.

Proposed Outcomes:

The study will be conducted in two phases. In Phase I, researchers will determine the current California distillation energy use profile by industry segment and type of distillation. The project will also identify industry segments that would benefit most from application of advanced distillation technology.

In Phase II, EPRI will assist the Commission with participation in a technical study, sponsored by British Petroleum and the US DOE, to determine the energy savings of advanced distillation for an ethylene plant in California.

Actual Outcomes:

In Phase I, researchers identified the current distillation energy use profile in California by industry segment and type of distillation. The team also determined the industry segments in California that would obtain the greatest benefit from advanced distillation methods.

Results indicated that if a conservative 25 percent of all existing distillation within the state is revamped using advanced distillation, the annual thermal energy savings is estimated to be 52 trillion Btu. Another 5 trillion Btu in annual savings could be achieved in potential near-term new chemical plant construction. The value of this potential 57 trillion Btu/yr savings is:

- \$142,500,000 (at a \$2.5/mmBtu fuel cost)
- \$285,000,000 (at a \$5/mmBtu) and
- \$570,000,000 (at \$10/mmBtu).

Overall electricity savings would be about 1 percent of the thermal savings (about 200 megawatts). In addition to fuel savings and electricity savings, capital cost savings of up to 40 percent or more could be achieved, representing savings on the order of \$800 million. Additional revenue could be realized through increased production. For the California petroleum refining industry (which represents more than 82 percent of the potential energy savings), the 25 percent of revamped distillation represents a 25 percent or more increase in production, which is worth on the order of \$1 million per year in additional profit at a conservative \$0.5/BBL profit margin.

The 57 trillion BTU/yr energy savings has an associated decrease in air pollution, water use, and wastewater discharges (including decreases of about 15 million ton/yr in carbon dioxide, 7,000 ton/yr NO_x, 27 million tons/yr fresh water, and 1.5 million tons/yr wastewater).

Phase II of the study began in 2002 and will extend through 2003. EPRI is assisting the Commission with participation in a technical study, sponsored by British Petroleum and the US DOE, to determine the energy savings of advanced distillation for an ethylene plant in California. Upon completion of the study, EPRI will prepare a site-specific analysis of this application and prepare a final report to the Commission. The report will present the Phase II results and describe the impact of energy savings from the application of advanced distillation.

EPRI will also develop technology transfer materials to inform and educate California industries about the benefits of advanced distillation to encourage its adoption in California.

Project Status:

Phase I is complete and covered in EPRI Report 1006719. Commission participation in Phase 2 of this study and a demonstration is in progress.

Emerging PQ Mitigation Product Demonstration at Customer Sites

Contract #: 100-98-001 **Project #:** 39

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$60,000

Contractor Project Manager: Ashok Sundaram
(650) 855-2304

Commission Contract Manager: Pramod Kulkarni
(916) 654-4637

Project description: This project's goal is to obtain real-life application experience with emerging power quality mitigation technology through demonstrations at customer sites. The demonstrations will enable the project team to characterize the limitations of the technology and identify opportunities for improvement. Customers involved in demonstration projects will obtain experience with the technology and will be able to train personnel in its application.

Power quality concerns continue to be an important factor affecting the productivity of California industries. The Commission is facilitating the development of new power quality mitigation hardware for customers. This project will take the technology development into the next step of demonstration projects to obtain experience and develop expertise in the application of the technology.

This project supports the PIER program objectives of:

- Improving the Reliability/Quality of California's Electricity by developing knowledge and procedures to solve power quality problems that cause equipment failures and process disruptions; and
- Improving the Energy Cost/Value of California's Electricity by reducing process inefficiency associated with power quality disturbances.

Proposed Outcomes:

1. Obtain experience and develop expertise in the application of new and emerging PQ mitigation hardware.
2. Characterize limitations and help identify opportunities for improvement of new technology developments in practical applications.
3. Develop estimates for operating and maintenance requirements as a function of the applications for the technology.

Actual Outcomes:

In 2001 the project team conducted site audits to determine the best location for demonstration. In addition, the requirements for PQ mitigation were determined for those sites.

The field demonstration was conducted in 2002. The device

installed was a neutral current filter. The intent of the demonstration was to determine the extent to which the device helped to conserve energy. Energy savings are possible due to the blocking of third harmonic current in the neutral conductor. This is applicable for single-phase non-linear loads supplied by a wye-connected transformer secondary. The measured results indicated that a small amount of energy savings is achieved, through the reduction of I²R losses in the neutral conductor. The payback time for the filter, based on those savings alone, was calculated. The Commission will now be able to show, for interested customers, that these filters can pay for themselves through energy savings, and also estimate how long that will take.

Status:

This project will be completed in early 2003.

RD&D Program Development for Ensuring Energy Supply for California's Electronics/E-commerce Industries

Contract #: 100-98-001 **Project #:** 48

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$960,000

Contractor Project Manager: Paul Radcliffe (650) 855-2720

Commission Contract Manager: Pramod Kulkarni (916) 654-4637

Project Description: The purpose of this project is to develop a comprehensive plan to ensure a reliable energy supply to California's electronics industry. The recent disruptions in electricity supply and escalating energy costs pose serious threats to this industry, which is a substantial contributor to the state's economic growth.

This project supports the PIER objective of:

- Strengthening California's economy by restoring the high-tech industry's confidence in their ability to obtain reliable energy at a reasonable cost.

Proposed Outcomes:

1. Develop an RD&D program plan that provides immediate and intermediate (five years maximum) solutions to help the electronics industry meet the energy challenge in California.
2. Implement a fast-track program that helps mitigate urgent problems currently faced by the industry and that provide public benefits as defined by the PIER program.
3. Transfer program results to principals in industry to gain maximum utilization in order to attain PIER program goals.

Project Status:

As of the end of 2002, four of six tasks in this program have been completed. A brief status of each task follows:

Task 1 – Two fast-track projects, selected by industry, are in progress to provide solutions for industry to cope with the current energy crisis:

- Demonstration of ultracapacitor technology for ride-through capability through power disruptions. Preliminary tests were conducted at a chip manufacturing facility. A three-month run on a non-critical application at the same site is planned for first quarter 2003.
- Field trials are being readied to demonstrate new software that enables energy users to take advantage of demand response programs and emerging real-time pricing programs. Trials will be completed in first quarter 2003.

Task 2 – An industry energy advisory group has been formed to help identify issues that can be solved through PIER Program RD&D. In addition, E2I is coordinating efforts with the Silicon Valley Manufacturing Group (SVMG), through a subcommittee dedicated to the CEC program. A series of web conferences have been held and an e-collaboration website established to engage industry and foster input on program direction.

Task 3 – Two regional workshops have been held, one in Silicon Valley and one in San Diego, to bring out local issues with energy supply and explore ideas for dealing with the full range of energy issues. While there was commonality regarding concerns with energy supply, diversity prevailed regarding priorities for remedies. Workshops were used to screen projects and prioritize activities to achieve potential solutions.

Task 4 – A web-based survey was completed that characterizes energy consumption patterns, power quality issues, and use of on-site generation among SVMG member companies.

Task 5 – A road map was completed, translating the feedback from the advisory group, the workshops, the needs survey, and other meetings into a "vision" of the desired future energy infrastructure in California. Issues, needs, knowledge gaps, and first-cut remedies were consolidated, through a collaborative process, into the Road map, translating stakeholder needs and aspirations into "technology development destinations."

Task 6 – Using the destinations and pathways outlined in the Road map, a coordinated portfolio of research, application, and demonstration projects is being prepared. This RD&D Plan will lay out for CEC review a multi-year Implementation Program for 2003 through 2006. The success of the program to date can be

attributed to effective collaboration. The process can remain effective if the Implementation Phase continues to engage public and private sectors in on-going review and re-direction. The RD&D Plan will be completed in first quarter 2003.

EPRI Program 2: Power Quality for Customer Systems

2.004: Power Quality and Electromagnetic Compatibility

Impacts on Robotics and Information Systems

2.005: Methodology for Determining Cost Recovery for “High Nine” Customers with On-Site Generation

2.007: Embedded Solution for Telecommunications and Internet Equipment

2.010: Advanced Flywheel and Ultracapacitor as Embedded Solutions for Advanced Machine Tools and Robotics

2.011: Cost Analysis and Reduction of Power Quality Mitigation Hardware

2.013: Power Quality and Powering E-Business Technology Watch

Contract #: 500-00-023

Contractor: EPRI

Subcontractors: PEAC Corporation

Contract Amount: \$150,082

Match Amount: \$591,559

Contractor Project Manager: Ashok Sundaram
(650) 855-2304

Commission Project Manager: Pramod Kulkarni
(916) 654-4637

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this program is to provide the Commission with information about power quality concerns and mitigation techniques at commercial and industrial facilities, including those that rely on sensitive robotics and automation systems. The program addresses the unique needs of the digital economy, and evaluates innovative powering options for the Internet and telecommunications industries. It also offers expert insight into power conditioning issues, along with guidance on the proper selection, application, and installation of power quality mitigation hardware.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California’s electricity by providing knowledge to California ratepayers about how to mitigate power quality problems that cause equipment failures and process disruptions.

Proposed Outcomes:

1. Gather knowledge and develop a test database of

susceptibility issues for robotics and automation systems. Explore device-to-device and device-to-environment power quality and electromagnetic compatibility issues.

2. Assess the benefit to the customer of providing utility service connections to customer sites that use on-site generation to fully offset their load. On-site generation is critical to meeting the “high nines” (up to 99.999999 percent) of reliability required by some customers, such as Internet data centers. On-site generation is also an integral part of many internal electric customer distribution systems. For service providers, this raises serious economic issues: How can a utility justify the cost of new customer connections if zero-net sales of energy will occur at that site? How can a utility recover transmission and distribution infrastructure investments when existing customers add distributed generation (DG)? There are also serious questions about how much capacity should be built into the transmission and distribution system to handle contingencies for periods when customer DG is not available. To address these issues, this project will provide an analytical review demonstrating the technical benefit of having the utility connection present. This will be extremely useful to the utility when trying to assess service connection fees that are fair to both the customer and utility company.
3. Design embedded solutions for telecommunications and Internet equipment. Embedded solutions for the digital economy can help to bridge the gap between the quality and reliability of power required and the ability of digital loads to survive the electrical environment. This groundbreaking, multi-year project will evaluate the current design criteria for digital loads and the performance of the baseline design with respect to power quality immunity, and fault tolerance.
4. Evaluate advanced flywheels and ultracapacitors as embedded solutions to improve the power quality performance of advanced machine tools and robotics. This project involves testing, technology demonstrations, and the integration of unique ride-through technologies into original equipment manufacturer equipment. In addition, a task force has been formed to facilitate development of industry standards for ride-through of such equipment.
5. Build on previous EPRI work that developed a methodology for system cost analysis and a probabilistic framework for conducting cost analysis for power quality mitigation hardware. The focus in 2002 is to apply the methodology to actual customer power conditioning demonstration projects conducted by EPRI. Life cycle costs will be developed for several power quality mitigation devices. The new methodology will be verified using an actual customer power conditioning demonstration project.
6. Provide late-breaking news on emerging power quality technologies and trends in powering e-business.

Actual Outcomes:

1. Power Quality and Electromagnetic Compatibility Impacts on Robotics and Information Systems
 - In 2002 EPRI performed voltage-sag tests to measure the baseline effects of voltage sags on industrial robots. General Motors provided access to automotive robots for testing. A technical brief, *Power Quality Impacts on Robotic Automation Systems* (1001667), describes the test results.
2. Methodology for Determining Cost Recovery for “High Nine” Customers with On-Site Generation
 - The project team drafted a technical report that assesses the technical benefit of providing a service connection to customer sites that use distributed generation to limit their energy utilization to essentially zero. The report is scheduled for publication in March 2003.
3. Embedded Solution for Telecommunications and Internet Equipment
 - A technical report (1001670) was drafted that evaluates the current design criteria for digital load power supplies and performance of the baseline design with respect to power quality immunity and fault tolerance. An embedded solution was designed to provide longer ride-through in “sleep” mode. The report will be available in late March 2003.
4. Advanced Flywheel and Ultracapacitor as Embedded Solutions for Advanced Machine Tools and Robotics
 - The project team prepared a technical report—*Advanced Machine Tool Embedded Solution* (1001673)—assessing the requirements of the robotics and machine tools industries to improve process uptime and identifying advanced technologies as embedded solutions for advanced machine tools and robotics. The report will be available in late March 2003.
5. Cost Analysis and Reduction of Power Quality Mitigation Hardware
 - A technical report—*Life Cycle Cost Analysis of PQ Mitigation Devices* (1001674)—was developed that presents a case study demonstrating how system cost analysis using a probabilistic framework is conducted with real-life data from a power quality mitigation hardware demonstration project. The report will be available in late March 2003.
6. Power Quality and Powering E-Business Technology Watch
 - Up-to-date information on power quality technologies and market trends is provided via web-based updates delivered electronically.

Project Status:

Commission participation in this target is ongoing.



Target 4 Customer Power Conditioning Solutions

Contract #: 500-00-023 **Project #:** 1

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$149,947

Match amount: \$1,486,946

Contractor Project Manager: Ashok Sundaram
(650) 855-2304

Commission Contract Manager: Pramod Kulkarni
(916) 654-4637

Project Description: The purpose of this project is to address the power quality (PQ) issues facing commercial and industrial energy users who are using devices that are more sensitive to PQ variations. Sensitive loads often are in extensive networks and automated processes, and many loads use power electronics for power conversion. These new, technology-driven changes have created a growing concern in many California businesses about the quality of power and its potential negative impact on productivity, downtime costs, lost product, energy utilization, global competitiveness, and the environment. These concerns focus on power quality mitigation equipment—that is, power conditioning and energy storage equipment that can protect loads from PQ variations.

EPRI research efforts have identified voltage sags and momentary interruptions as the two most important categories of power quality variations affecting end users. Traditional power quality mitigation technologies such as uninterruptible power supply systems can address these problems but at a substantial cost and sometimes with marginal performance. EPRI's Customer Power Conditioning Solutions Target provides information about the best and most cost-effective power conditioning and energy storage equipment available, and the technical expertise to help California ratepayers use the equipment properly. This target provides information on power conditioning issues, along with guidance on the proper selection, application, and installation of power conditioning and energy storage equipment. It also identifies and demonstrates new and innovative technologies with high commercialization potential such as advanced flywheels and ultracapacitors.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by providing knowledge to California ratepayers about how to mitigate power quality problems that cause equipment failures.

Proposed Outcomes:

1. Produce system compatibility test protocols for determining the feasibility of applying local generation and its effects on power quality in customer environments.

2. Investigate the susceptibility of advanced computer numerically controlled (CNC) machine tools to voltage sags, assess the possibilities of cost-effective embedded power quality solutions, and illustrate the concept of embedded solutions with case studies.
3. Demonstrate how to conduct a life-cycle cost analysis for a power quality mitigation project at a commercial customer site and incorporate statistical information in the decision-making process.
4. Develop case studies to evaluate the power quality implications of hybrid systems consisting of power quality mitigation hardware and energy delivery and energy storage systems.
5. Provide laboratory data and performance analysis of a proton exchange membrane (PEM) fuel cell designed for power quality applications.
6. Conduct an EPRI Tailored Collaboration (TC) project entitled "Assessing the Impact of Power Quality for California Industries."
7. Conduct an EPRI TC project entitled "Guidebook on Power Quality Guidelines for Energy Saving Products."
8. Conduct an EPRI TC project entitled "Emerging PQ Mitigation Product Demonstration at Customer Sites."
9. Conduct an EPRI TC project entitled "Optimization of Electric Energy Consumption in Marginal California Oilfields."

Actual Outcomes:

1. A report—Distributed Generation Source Stiffness and Its Impact on Voltage Distortion, 1005922—was published on an evaluation of voltage distortion resulting from application of nonlinear load for three different types of rotary generators and one inverter-based generator.
2. A report—PQ Mitigation Technology, Market, and Cost: Advanced Machine Tool 2001 Efforts, 1005923—was published on the effects of voltage sags on advanced machine tools and the use of power conditioning equipment to mitigate these disturbances. A report—Embedded Solutions for Advanced Machine Tools: Field Demonstration and Test Results, 1005924—was published on field case studies related to voltage sag testing of computerized numerical control (CNC) machining.
3. A report—Development of Probabilistic Analysis Tools for Optimal Selection of Power Quality Mitigation, 1005925—was published to provide a comprehensive methodology for performing an economic analysis of the life-cycle cost for power quality mitigation hardware solutions.
4. A report—Case Studies, 1005926—was published on power quality implications of an existing hybrid installation.
5. A report—Evaluation of a 3-kW Proton Exchange Membrane (PEM) Fuel Cell 1005927—was published to document results of a demonstration of a PEM fuel cell for power quality

applications such as UPS systems and replacement for lead-acid batteries.

6. Tailored Collaboration: Assessing the Impact of Power Quality for California Industries. Researchers developed and distributed a survey to identify the perceptions of California industries regarding the quality of power they receive, the most common issues, and the most appropriate R&D to undertake to solve the problems faced by industry. The survey results were analyzed, and a draft report was submitted to the CEC for review and comment. Once comments are received, EPRI will publish the final report. This information will improve the productivity of California industries by reducing the impact of power quality on sensitive loads, and by avoiding downtime costs and lost product.
7. Tailored Collaboration: Guidebook on Power Quality Guidelines for Energy-Saving Products. The project team identified the characteristics of power quality issues related to energy-saving products, developed guidelines for minimizing power quality impacts, and created tools for evaluating energy-saving claims from “black-box” type energy-saving devices. This information will remove one of the barriers to application of energy-saving devices by California industries, and enable users to apply these products without power quality impacts.
8. Tailored Collaboration: Emerging PQ Mitigation Product Demonstration of Customer Sites. Investigators arranged for the field demonstration of power quality mitigation technologies at California industry locations. Technology evaluations and economic assessments were conducted. Site selection and survey and auditing of the site are under way. Once these are complete, EPRI will publish the results of Phase I and produce a draft proposal for Phase II. The field demonstration will be conducted in Phase II. Results will offer California industries real-life application experience with new technologies.
9. Tailored Collaboration: Optimization of Electric Energy Consumption in Marginal California Oilfields. Oilfield surveys completed by May 2001 collected data from 19 fields. The field data represented 939 producing wells, of which 91 percent were rod-pumped wells. Existing and new technologies were reviewed to improve oilfield electrical efficiency. Extrapolation of these results to all wells in California could result in a total benefit that could exceed 139 GWh/M in reduced power consumption and a demand reduction exceeding 221 MW. If these suggestions were implemented, a reliable system-wide demand reduction may be realized by energy suppliers through reduction of the need for additional generation and power infrastructure. Results were published in Optimization of Electric Energy Consumption in Marginal California Oilfields, 1006487.

Project Status:

Commission participation in this target is complete.

Program 2 Power Quality for Customer Systems

- 2.004:** Power Quality and Electromagnetic Compatibility Impacts on Robotics and Information Systems
- 2.005:** Methodology for Determining Cost Recovery for “High Nine” Customers with On-Site Generation
- 2.007:** Embedded Solution for Telecommunications and Internet Equipment
- 2.010:** Advanced Flywheel and Ultracapacitor as Embedded Solutions for Advanced Machine Tools and Robotics
- 2.011:** Cost Analysis and Reduction of Power Quality Mitigation Hardware
- 2.013:** Power Quality and Powering E-Business Technology Watch

Contract #: 500-00-023 **Project #:** 30-35

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$150,083

Match amount: \$591,559

Contractor Project Manager: Ashok Sundaram
(650) 855-2304

Commission Contract Manager: Pramod Kulkarni
(916) 654-4637

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this program is to provide the Commission with information about power quality concerns and mitigation techniques at commercial and industrial facilities, including those that rely on sensitive robotics and automation systems. The program addresses the unique needs of the digital economy, and evaluates innovative powering options for the Internet and telecommunications industries. It also offers expert insight into power conditioning issues, along with guidance on the proper selection, application, and installation of power quality mitigation hardware.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California’s electricity by providing knowledge to California ratepayers about how to mitigate power quality problems that cause equipment failures and process disruptions.

Proposed Outcomes:

1. Gather knowledge and develop a test database of susceptibility issues for robotics and automation systems. Explore device-to-device and device-to-environment power quality and electromagnetic compatibility issues.

2. Assess the benefit to the customer of providing utility service connections to customer sites that use on-site generation to fully offset their load. On-site generation is critical to meeting the “high nines” (up to 99.9999999 percent) of reliability required by some customers, such as Internet data centers. On-site generation is also an integral part of many internal electric customer distribution systems. For service providers, this raises serious economic issues: How can a utility justify the cost of new customer connections if zero-net sales of energy will occur at that site? How can a utility recover transmission and distribution infrastructure investments when existing customers add distributed generation (DG)? There are also serious questions about how much capacity should be built into the transmission and distribution system to handle contingencies for periods when customer DG is not available. To address these issues, this project will provide an analytical review demonstrating the technical benefit of having the utility connection present. This will be extremely useful to the utility when trying to assess service connection fees that are fair to both the customer and utility company.
3. Design embedded solutions for telecommunications and Internet equipment. Embedded solutions for the digital economy can help to bridge the gap between the quality and reliability of power required and the ability of digital loads to survive the electrical environment. This groundbreaking, multi-year project will evaluate the current design criteria for digital loads and the performance of the baseline design with respect to power quality immunity, and fault tolerance.
4. Evaluate advanced flywheels and ultracapacitors as embedded solutions to improve the power quality performance of advanced machine tools and robotics. This project involves testing, technology demonstrations, and the integration of unique ride-through technologies into original equipment manufacturer equipment. In addition, a task force has been formed to facilitate development of industry standards for ride-through of such equipment.
5. Build on previous EPRI work that developed a methodology for system cost analysis and a probabilistic framework for conducting cost analysis for power quality mitigation hardware. The focus in 2002 is to apply the methodology to actual customer power conditioning demonstration projects conducted by EPRI. Life cycle costs will be developed for several power quality mitigation devices. The new methodology will be verified using an actual customer power conditioning demonstration project.
6. Provide late-breaking news on emerging power quality technologies and trends in powering e-business.

Actual Outcomes:

1. Power Quality and Electromagnetic Compatibility Impacts on

Robotics and Information Systems

- In 2002 EPRI performed voltage-sag tests to measure the baseline effects of voltage sags on industrial robots. General Motors provided access to automotive robots for testing. A technical brief, *Power Quality Impacts on Robotic Automation Systems* (1001667), describes the test results.
2. Methodology for Determining Cost Recovery for “High Nine” Customers with On-Site Generation
 - The project team drafted a technical report that assesses the technical benefit of providing a service connection to customer sites that use distributed generation to limit their energy utilization to essentially zero. The report is scheduled for publication in March 2003.
 3. Embedded Solution for Telecommunications and Internet Equipment
 - A technical report (1001670) was drafted that evaluates the current design criteria for digital load power supplies and performance of the baseline design with respect to power quality immunity and fault tolerance. An embedded solution was designed to provide longer ride-through in “sleep” mode. The report will be available in late March 2003.
 4. Advanced Flywheel and Ultracapacitor as Embedded Solutions for Advanced Machine Tools and Robotics
 - The project team prepared a technical report—*Advanced Machine Tool Embedded Solution* (1001673)—assessing the requirements of the robotics and machine tools industries to improve process uptime and identifying advanced technologies as embedded solutions for advanced machine tools and robotics. The report will be available in late March 2003.
 5. Cost Analysis and Reduction of Power Quality Mitigation Hardware
 - A technical report—*Life Cycle Cost Analysis of PQ Mitigation Devices* (1001674)—was developed that presents a case study demonstrating how system cost analysis using a probabilistic framework is conducted with real-life data from a power quality mitigation hardware demonstration project. The report will be available in late March 2003.
 6. Power Quality and Powering E-Business Technology Watch
 - Up-to-date information on power quality technologies and market trends is provided via web-based updates delivered electronically.

Project Status:

This project is complete.

Program 12 Production, Manufacturing, and Electronics Industries

12.004: Cooling Water Cost Comparison Model

12.006: Electrotechnologies for Waste Reclamation

Contract #: 500-00-023 **Project #:** 36-37

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$9,000

Match amount: \$6,285

Contractor Project Manager: Keith Carns (314) 935-8598

Commission Contract Manager: Pramod Kulkarni
(916) 654-4637

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: This program provides knowledge and tools to help production, manufacturing and electronics industries use electrotechnologies to solve environmental issues such as water treatment and waste reclamation in an informed, cost-effective manner.

This project supports the PIER Program objectives of:

- Supporting the development of new electricity applications to solve environmental problems by providing information and evaluation tools that help businesses apply electrotechnologies for water treatment and waste reclamation; and
- Providing environmentally sound electricity by expanding the use of electrotechnologies that replace or supplement processes that may harm the environment.

Proposed Outcomes:

1. Develop a cooling water cost comparison model that allows users to evaluate and compare the costs of ozone cooling water technologies. The model will be available as an Excel spreadsheet that allows insertion of specific data to be analyzed.
2. Develop information on electrotechnologies for waste reclamation to support and promote the use of efficient, environmentally sound reclamation and recycling processes.

Actual Outcomes:

1. Cooling Water Cost Comparison Model
 - A compact disk containing an Excel spreadsheet cost comparison model and examples was produced and delivered in 2002.
2. Electrotechnologies for Waste Reclamation
 - A technical report—*Electrotechnologies for Waste Reclamation* (1005869)—was developed and made available as a downloadable PDF file or delivered on a compact disk.

Project Status:

This project is complete.

Program 13 Agriculture and Food Technology Alliance (AFTA)

13.001: Agri-Food Processing and Production Technologies

13.003: Agri-Food Technologies Window

Contract #: 500-00-023 **Project #:** 38-39

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$25,000

Contractor Project Manager: Keith Carns (559) 642-2082

Commission Contract Manager: Pramod Kulkarni
(916) 654-4637

Project Description: The purpose of this program is to provide information and guidance to help energy companies, production agriculture operations, and food processors meet the demand for a safe and adequate food supply while meeting the newly mandated rules of the Clean Air and Clean Water Acts. Projects focus on food safety, energy efficiency, and environmentally sound processes for solid and liquid waste disposal. All projects have direct applicability or are tied to processes used extensively in California agricultural production and food processing.

AFTA offers technical assistance and customer support in all areas of agricultural production and food processing. The alliance's base of knowledge and expertise may be applied to diverse areas such as animal waste management, aquaculture, membrane and other concentration technologies for treating food production and food processing wastewater streams, food safety and regulatory issues, crop production, and handling and irrigation technologies. AFTA holds joint meetings and workshops for customers, with topics ranging from ozone usage for both agriculture and food processing, to biofuels, membrane technologies, flocculation methodologies, and legislative and regulatory concerns. These meetings allow customers the opportunity to network, discuss customers' needs and provide solutions, and evaluate and discuss future projects and programs. By having available communication tools for common or reoccurring problems, the program can often solve problems before they begin. AFTA staff also tracks emerging technologies in the Agri-Food industry and makes the findings available to program participants.

This project supports the PIER Program objectives of:

- Improving the environment, public health and safety by providing information on electrotechnologies that help California food producers and processors ensure a safe and adequate food supply; and

- Providing environmentally sound electricity by expanding the use of electrotechnologies that replace or supplement processes that may harm the environment.

Proposed Outcomes:

1. Develop an Agri-Food Processing and Production Technology Solution Package for the Commission that is tailored to the needs of the California agriculture and food processing industries. The solution package may include consulting meetings between AFTA and Commission representatives, as well as the delivery of technical reports, agri-food news updates, and other information products.
2. Provide a window on news and developments in the agri-food sector by monitoring legislative, regulatory and technical publications, industry contacts and emerging technologies, and making this information available to participants in a timely manner.

Actual Outcomes:

1. Agri-Food Processing and Production Technology Solution Package
 - Keith Carns, AFTA Director and Vice President of Global Energy Partners, paid a consulting visit to Commission headquarters and met with Pramod Kulkarni and other Commission staff to discuss California agri-food issues and potential research projects, including R&D on an advanced ethanol production process utilizing feedstock other than #2 yellow corn.
 - The following AFTA publications were published and delivered in 2002:
 - *Shelf Life and Pathogen Growth in Irradiated Sausage* (1006955)
 - *Enhancement of Food Safety* (1006956)
 - *Ozone Applications in Fish Farming* (1006975)
 - *Cumberland County College Fish Barn: An Aquaculture Education & Commercial Demonstration Facility* (August 2002)
 - *Product Concentration: an Assessment of EPRI Freeze Technologies 1985-2002* (1007399)
 - *Treatment of Cut Vegetables with Aqueous Ozone: Technical Assessment* (1007465)
 - *Ozone Improves Processing of Fresh-Cut Produce: Tech Application* (1007566)
2. Agri-Food Technologies Window
 - Five issues of Food Industry Currents were published in 2002. This quarterly newsletter reports on agri-food industry developments and trends. In May a special fifth edition of the newsletter was published that discussed the implications of the 2002 Farm Bill.
 - The Commission received listings of all nonproprietary AFTA publications, newsletters, Industrial News Today, e-

mail alerts, meeting invitations, and hotline access to discuss problems, opportunities and potential projects with the AFTA staff.

Project Status:

This project is complete.

TARGET 23/2.6 CHEMICALS, PETROLEUM AND NATURAL GAS

Contract #: 100-98-001

Contractor: EPRI

Subcontractors: Advanced Resources International, Inc; Chemicals & Petroleum Management, Inc.; Edison Technology Solutions; El Paso Energy Corp.; Hawaiian Electric Company Inc; Kennedy/Jenks Consultants Inc; Lockheed Martin Energy Research Corporation; Massachusetts Institute of Technology; Niro Process Technology; Taratec Corporation; University Of Florida; University of Patras; Veritech, Inc; ISOPro International; Optima Engineers & Co.; ProWrite Inc.; Resource Dynamics

Contract Amount: 1999: \$195,038

2000: \$253,140

Match Funding: 1999: \$582,206

2000: \$584,321

Contractor Project Manager: Ed Fouche (919) 515-7550

Commission Project Manager: Paul Roggensack
(916) 654-6560

Commission Contract Manager: Gary Klein
(916) 653-8555

Project Description: The purpose of this project is to provide chemical and petroleum companies methods to cut energy costs while improving productivity and yield. It will also provide information for companies reviewing options for generating on-site electricity and seeking the latest and most cost-effective advances in pollution control. To stay productive and profitable, decision-makers in this market sector must address a host of economic and environmental concerns. EPRI provides information and technical expertise on advanced systems for wastewater reduction, soil remediation, and fluid transport to increase the value of electricity as this segment of California industry enhances environmental compliance and lowers operating costs.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing information on reducing wastewater discharge and improving soil remediation techniques for the chemical, natural gas, and petroleum industry; and
- Improving the environmental and public health costs/risks of California's electricity by providing information to reduce the

impacts on the environment by the chemical, natural gas, and petroleum industry.

Proposed Outcomes:

1. Encourage the use of ozonation in process industries through a demonstration project at an industrial site in California.
2. Improve the understanding of power quality needs of large industrial complexes.
3. Provide information to encourage reduction of wastewater for process industries.
4. Provide marketing and communication tools to increase use of energy efficient technology in chemicals and petroleum process.
5. Provide information to increase use of energy efficient technologies in chemical, natural gas, and petroleum processes.
6. Conduct a Tailored Collaboration entitled “Development and Demonstration of Liquid Membrane Technology for MTBE Mitigation in Aqueous Streams” for the reduction and removal of MTBE contamination in the California water supply.
7. Conduct a Tailored Collaboration entitled “Hydrogen Pinch Studies at Arco’s Wilmington (CA) Refinery” in order to identify process and equipment changes to improve hydrogen recovery in the most cost-effective way.

Actual Outcomes:

1. This proposed outcome was replaced by the Tailored Collaboration entitled “Characterizing Power Quality and Specifying Solutions at a Food Processing Plant” conducted under EPRI Target 38, Power Quality for Improved Industrial Operations.
2. This proposed outcome was replaced by the Tailored Collaboration entitled “Hydrogen Pinch Studies at Arco’s Wilmington (CA) Refinery” and described in item #7 below.
3. Wastewater reduction.
 - A comprehensive report was published that identifies and characterizes current and potential water management technologies.
 - A Water Management Workshop was held in conjunction with EPRI’s AIChE’s Center for Waste Reduction Technologies.

4. The *Supply Side Management Kit* was produced, including brochures, guidebooks, case studies, and other promotional and education materials regarding electricity and gas sales, distribution system reliability, cogeneration, tariff analysis, and asset management.
5. Information to increase use of energy efficient technologies.
 - A scoping study report was published on enhanced oil recovery technologies.
 - A report was published on Pinch screen analysis to maximize process energy efficiency.
 - A report was published about a promising membrane process that delivers environmental and economic benefits by recovering valuable feedstocks in polyolefin plants.
 - A TechApplication document was published outlining the economics and emission reduction advantages of electric compression for natural gas storage and pipelines.
 - Market and technical information were compiled about a major business trend in the chemicals industry—the move into the high-margin segments of life sciences and specialty chemicals.
 - A report was published on trends, issues, and opportunities in healthcare.
 - A monthly newsletter was published on industrial trends and developments.
 - The Third Gas/Electric Partnership Symposium was held, bringing together representatives from electric power, gas pipeline, and service industries to pursue partnerships.
 - An overview course was presented on the petrochemical industry.
6. EPRI completed a final report—*Development of Supported Polymeric Liquid Membrane Technology for Aqueous MTBE Mitigation (1006577)*—in November 2002. A technology transfer seminar was held in February 2002.
7. For a new methodology called Hydrogen Pinch, the project team collected and analyzed data at Arco’s refinery in Los Angeles, and made recommendations for applying the methodology in efforts that could yield a total annual savings for the refinery of about \$4.5 million.

Status:

This project is complete.



**Projects Funded through
the Renewable Energy
Technologies
PIER Program Area**

- Projects Funded in 2002
- Projects In Progress
- Projects Completed



California Biomass Consortium

Contract #: 500-01-016

Contractor: Regents - Davis

Contract amount: \$415,716

Contractor Project Manager: Bryan M. Jenkins
(530) 752-1422

Commission Contract Manager: Valentino Tiangco Ph.D.
(916) 654-4664

Project Description: The purpose this project is to create a single forum and focal center at the State level to address the issues and needs besetting biomass energy development in California. The Consortium will serve as a unique forum for coordinating biomass energy systems development in the state and will provide additional expertise to the Commission in helping to achieve timely review and implementation of policy concepts and proposed system and technology innovations.

The mission of the Consortium is to enhance the development of sustainable and effective biomass energy systems for the state of California. To fulfill this mission, the Consortium plans to administer a comprehensive statewide program in scientific research and innovation, technology development, demonstration, and deployment, and education and training, and to support and integrate efforts of the State in advancing the state-of-knowledge and state-of-the-art in efficient, safe, reliable, affordable, and environmentally sound biomass energy systems. The Consortium plans to accomplish this mission through the close cooperation of representatives of the State of California, its universities and academic institutions, the state's biomass and energy industries and environmental organizations, agencies and laboratories of the federal government, and other organizations and institutions.

Additional goals include initiating activities under several of the primary topical areas, including research, development, demonstration, and deployment, education and training, public outreach, policy, and standards. The Consortium will include representatives from the California Energy Commission and other state agencies, the University of California, the California biomass industry, energy suppliers, the environmental community, federal agencies, national laboratories, other industry groups and institutes, and other academic and related organizations.

This project supports the PIER objectives of:

- Improving the cost/value, environmental and public health costs/risks, reliability/quality, and safety of California's electricity by promoting and advancing the state's renewable biomass energy industry; and
- Providing more energy choices for California ratepayers and

maximizing the market connectivity of biomass technologies developed through the PIER program.

Proposed Outcomes:

- Organize and manage a diverse consortium advisory group (the Consortium) to provide immediate expertise in areas pertaining to biomass energy including technologies, resources, design, siting, construction, operation and maintenance, generation, and modeling.
- Organize an Executive Board to administer the overall function of the Consortium.
- Enlist staff to carry out the day-to-day and project oriented activities of the Consortium.
- Establish of a physical focal point for biomass energy related questions/activities in the state.
- Develop topical papers specific to California that evaluate existing biomass resource inventories and the potential for new biomass resource development and markets. In addition, the papers will assess technical, economic, and environmental performance of current and potential future biomass power generation systems that address California electricity needs with respect to reducing congestion and increasing peak generating capacity. These papers will be designed to establish the background for bioenergy development in the state and to generate recommendations, directions, and priorities for policy, research, demonstration, education, standards, and other activities and projects needed to advance biomass power systems.
- Support statewide biomass-related Geographical Information System (GIS) modeling efforts and enhance state level biomass inventory data.
- Create of a California Biomass Facilities Reporting System to provide up-to-date information on biomass power facilities and facility performance.
- Develop a Consortium web site for disseminating and improving public access to biomass information, data, white papers, and Consortium activity reports.

Project Status:

The contract is waiting for approval from the Department of General Services (DGS) and project work is expected to begin in February 2003.

California Ocean Wave Energy Resource Evaluation

Contract #: 500-01-018

Contractor: San Diego State University (SDSU)

Subcontractors: Neptune Sciences Dr, James Wilson , George Hagerman, Nick Graham

Contract Amount: \$120,000

Contractor Project Manager: Dr. Asfaw Beyene,
(619) 594-6207

Commission Contract Manager: David Navarro,
(916) 654-4618

Project Description: The purpose of this project is to conduct an ocean wave energy resource evaluation to determine the potential energy off California's coast and identify potential sites best suited for particular wave energy converters (WEC) technologies being developed. The U.S. DOE Energy Efficiency and Renewable Energy (EREN) website states that the total power of waves breaking on the world's coastlines is estimated at 2 to 3 million megawatts, and, in favorable locations, wave energy density can average 65 megawatts per mile of coastline. An earlier evaluation of the potential energy in ocean waves off California's northern coast estimates there is an average of 30-40 kW/m of available energy. Harvesting 20% of the northern California potential wave energy could provide upwards of 500 MW of electricity per year.

SDSU and Neptune Sciences will:

1. Compile a statistical database of wave characteristics off the California coastline based on buoy measurements and hindcast modeling. The database will include annual wave height, 20-year wave height and wave period by season compiled as a function of geographic location in a one-degree latitude and longitude grid;
2. Estimate the potential energy available from ocean wave resources and include annual energy flux and annual peak energy flux;
3. Identify factors critical to the development and placement of WECs relevant to California's coast and specific geographical conditions including information on the commercial status, technical performance, and cost characteristics of available WEC technologies. Additionally, local and state agency permitting or regulatory requirements associated with deploying WECs off California's coast will be identified; and
4. Assess the magnitude of electricity that can be developed from ocean wave energy resources off California's coast, given the technical, economic and environmental considerations identified and identify the optimal locations for specific and available WEC systems along California's coast.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing a renewable energy technology that can continually feed low-cost electricity into the grid and can be used in remote, site-specific locations where it is prohibitively expensive to bring utility power lines;

- Improving the reliability of California's electricity by helping further the development of a renewable energy technology that generates electricity 24 hrs/day; and
- Improving the environment, public health and safety of California's electricity by providing information that can lead to deployment of an environmentally clean electric generation technology.

Proposed Outcomes:

- Statistical database of California wave characteristics
- Estimation of potential energy to California from ocean waves
- Identify critical factors to the development and placement of WECs in California; and
- Site-specific magnitude of energy potential relative to optimal location along California coastline.

Status:

The project is on schedule and within budget. The draft final report is due. The contract end date is March 31, 2003

Clean Power Estimator

Contract #: 500-01-029

Contractor: Clean Power Research

Contract amount: \$43,500

Contractor Project Manager: Tom Hoff (707) 224-9992

Commission Contract Manager: George Simons
(916) 654-4659

Project Description: The goal of this project is to assist California consumers in evaluating the economic feasibility of cool roofs (primarily roofs with high solar reflection and high thermal emittance), radiant barriers, and building integrated photovoltaics (BIPV) by:

- a) documenting the energy impacts associated with the various products based on existing research results
- b) constructing an analytical method that quantifies the electricity savings based on these research results; and
- c) integrating the analytical capability into the Commission's version of the Clean Power Estimator program.

This project will accomplish this goal by extending the capability of the Commission's version of the Clean Power Estimator tool to be able to assess the economic benefits of cool roofs, radiant barriers, and BIPV. The updated tool will be made available to California consumers on the internet-based Clean Power Estimating Tool.

This project contributes to the PIER program objectives of:

- Improving the energy cost/value of California’s electricity by enabling consumers to assess the benefits of cool roofs, radiant barriers, and BIPV systems to determine if they want to purchase such technologies to decrease heat gain in their building structure or generate their own electricity.

Project Status:

The Contractor has completed the first two tasks of documenting the energy impacts associated with the various products based on existing research results and constructing an analytical method that quantifies the electricity savings based on these research results. The last task of integrating these into the web based Clean Power Estimator tool is currently underway.

Hetch Hetchy Water & Power/SF PUC and Public Renewables Partnership

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power, San Francisco

Subcontractors: Electrinx Corporation, Distributed Generation Systems, Microgy, GeothermEx, Accurex, ImaginIt, E3, McNeil Technologies, Aqua Energy, Duke Solar, Millenium Energy, Stirling

Contract amount: \$5,854,585

Match amount: \$1,429,181

Contractor Project Manager: Fred Weiner (415) 544-3815

Commission Contract Manager: Valentino Tiangco Ph.D. (916) 654-4664

Project Description: The purpose of this programmatic renewable project is to advance renewable energy science and technology in ways that allows California public utilities, energy service providers and utility distribution companies to integrate renewable resources as a principal component of their resource portfolios. Hetch Hetchy Water and Power (Hetch Hetchy)/San Francisco Public Utilities Commission (SFPUC) is the prime contractor of this programmatic renewable project. Hetch Hetchy/SFPUC is a member of The Public Renewables Partnership (PRP) (formerly Power Renewable Energy Action Team (PPREAT)). PRP is a broad, new collaboration of California municipal utilities, irrigation districts, potential community aggregators (including non-utility municipalities), and renewable energy developers and others aimed at utilizing renewable resources to help ensure the cost-effectiveness, reliability and resource diversity of California’s electricity system. The group works through a collective planning process to investigate the feasibility of and benefits to California’s power system from a comprehensive resource-based generation portfolio that includes a significant proportion of renewable energy. Center for Resource Solutions (CRS) is the key subcontractor and program administrator of this programmatic project.

Hetch Hetchy/SFPUC will be the first recipient and customer of the successes of this programmatic renewable project. Currently, San Francisco’s electric system is vulnerable to any disruptions. Because the City of San Francisco is located at the end of the peninsula, there is a limited ability to import electricity into San Francisco. All the power coming into the city follows one transmission pathway from an electric substation near the City of San Mateo to another substation near San Francisco’s Cow Palace. In December 1998 this infrastructure was disrupted resulting in an economically damaging daylong blackout for parts of the City. During periods of peak demand the City can import over existing transmission lines only about 60 percent of the power needed to meet its needs. Therefore, San Francisco is dependent on the operation of power plants located in the city. Currently, power plants are located at just two sites, Hunter’s Point and Potrero, both in southeast San Francisco. The plants located at these sites are old, inefficient, prone to breaking down and many times more polluting than new power plants.

This programmatic renewable project will help accelerate the implementation of the energy plan of the City of San Francisco in providing a coherent framework for assessing San Francisco’s opportunities to overcome its electric infrastructure vulnerabilities and assure reliable, affordable and sustainable sources of electricity. The energy plan of the City includes the development of renewable power. The desire to locate renewable energy technologies within the city became evident when San Franciscans voted overwhelmingly for Proposition B, which authorized \$100 million in bonds to finance renewable and efficiency projects in City facilities. In addition, proposition H was also passed, which gives the Board of supervisors the power to issue revenue bonds for renewable and efficiency projects in the private sector.

In this programmatic project, Hetch Hetchy/SFPUC together with PRP will work through a collective planning process to investigate the feasibility and benefits to California’s power system from a comprehensive resource-based generation portfolio that includes a significant proportion of renewable energy. Ultimately, this programmatic project will develop long-range renewable power procurement strategies that can compete head-to-head on value with traditional utility power resources. Hetch Hetchy/SFPUC will achieve its goals through a combination of management and technical activities. In particular, by focusing on the advancement of renewable energy technology and science, Hetch Hetchy/SFPUC will ensure the availability of cost-effective renewable energy supply in both the near and long-term. The specific elements of this programmatic renewable project are designed to achieve – in a coordinated fashion – overarching technical and economic objectives of:

- Accelerating the cost effectiveness and value of using renewable energy in the near term as a significant component of a resource portfolio;
- Advancing the development of cutting-edge renewable technologies to ensure the increasing availability of renewable options in the longer term; and
- Supporting the application of renewable energy sources in targeted, distributed generation applications to increase grid reliability, reduce transmission and distribution upgrade costs, meet peak demand and reduce transmission congestion, and satisfy customer needs.

This programmatic renewable project consists of one administrative project and 10 linked renewable energy projects with the common aim of utilizing renewable resources to help ensure the cost-effectiveness, reliability and resource diversity of California's electricity system and achieving the overall goal stated above.

The specific projects by emphasis area are listed below:

Emphasis Area 1: Assessing and Targeting Renewable Energy Development

- Project 1.1 Feasibility of Interconnecting Pacific HVDC Intertie
- Project 1.2 New Wind Site ID and Qualification
- Project 1.3 New Geothermal Resource Assessment

Emphasis Area 2: Increasing Affordability of Existing Renewable Energy Facilities

- Project 2.1 Upgrading Existing Geothermal Sites

Emphasis Area 3: Expanding Affordability and Diversity Using Renewable Distributed Generation

- Project 3.1 Distributed Generation Assessment
- Project 3.2 Biomass Project Distributed Generation Value Analysis

Emphasis Area 4: Developing Renewable Energy Technologies for Tomorrow's Electricity System

- Project 4.1 Solar Thermal Parabolic Trough Powerplant
- Project 4.2 Hybrid Biofuel/Natural Gas
- Project 4.3 Energy Storage for Renewable Generation

Emphasis Area 5: Integrating Program Findings To Ensure Broad Replicability

- Project 5.1 Technical Project Performance integration

This Programmatic Project supports the PIER Program objectives of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of

advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system;

- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers by providing cleaner sources/choices of energy.

Programmatic Project Status:

The project/program kickoff meeting was held at the Energy Commission on September 11, 2002. The technical kickoff meeting was held on October 30, 2002. The schedules of all projects were updated. Deliverables for all projects were defined and fully characterized. Specific dates for the Renewable Programmatic Advisory Committee (RPAC) meetings and Critical Project Review (CPR) meetings were identified. Project tracking system and other administrative protocols were initiated and established. Match funding requirements with the prime contractor and subcontractors were all secured and documented. Public and private web based project information has been established and is now available at: <http://www.resource-solutions.org/PIER/PIERindex.htm>

The first RPAC meeting was held on January 14, 2003 and received favorable comments from RPAC members to proceed on project activities, as scheduled. The subcontracts are currently going through an approval process and project activities have just started.

In general, this programmatic project is ongoing and currently on schedule and within budget.

Emphasis Area 1: Assessing and Targeting Renewable Energy Development

PROJECT 1.1 FEASIBILITY OF INTERCONNECTING PACIFIC HVDC INTERTIE

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: Electronix Corporation

Project Amount: \$311,005

Match Funding: \$96,076

Contractor Project Manager: Fred Weiner (415) 554-3185,

Subcontractor Project Manager: Dennis Woodford (204) 953-1832

Commission Project Manager: Valentino Tiangco, Ph.D. (916) 654-4664

Commission Technical Lead: Elaine Sison-Lebrilla, P.E. (916) 653-0363

Project Description: The purpose of this project is to explore

the technical and financial aspects of interconnection to the Pacific high-voltage DC (HVDC) intertie to bring new wind and geothermal resources to the California market. The HVDC intertie near the California-Nevada border may present opportunities to bring several thousand megawatts of new geothermal and wind resources into California.

The specific project objectives are:

- Determine costs to interconnect a combination of wind and geothermal generation resources to the Pacific HVDC Intertie at single and multiple points near the Nevada-California border in amounts of 500, 1000, 1500, and 2000 MW.
- Determine the available transfer capacity and technical feasibility of any potential AC transmission interconnection points and options that should be considered as an alternative strategy to interconnection into the Pacific HVDC Intertie.
- Determine the optimal interconnection point(s) based on a technical analysis of available geothermal and wind resources near the California-Nevada border.
- Determine the relative costs and advantages of developing a stand-alone AC collector grid for these renewable energy resources versus using the existing AC collector grid.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system.
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions.
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers by providing cleaner sources/choices of energy.

Proposed Outcomes:

- A large source of renewable energy will become available for the California market, and because of the nature of this energy and its location, will add to the diversity of energy sources available to the State.
- A corresponding amount of less environmentally friendly energy will be displaced.
- Potentially stabilize energy prices in California due to the greater availability of renewable energy resources. Non-volatile energy pricing may be possible from the proposed renewable energy sources, with a stabilizing effect on overall electric energy pricing in California.

The following performance indices can be used to determine

the effectiveness of the proposed interconnection:

- How much new renewable energy generation can be transmitted to customers in Northern California (where the need is greatest) and to Southern California?
- What is the expected return on investment for the recommended transmission option? This will be a main indicator of the project feasibility.
- What percentage of the Pacific HVDC Intertie energy capacity is utilized on a yearly basis? The amount of power and energy that is available to be delivered to Southern California through the Pacific HVDC Intertie will determine the capacity of the renewable resources that can be used, thus impacting the economic effectiveness of the project.
- What environmental impact does the new interconnection have? Although an environmental impact study is not included in this contract, the minimization of new transmission facilities is one measure of environmental impact. The less new transmission, the less environmental impact.
- Added energy from the development of renewable resources will increase the reliability of energy supply to the California power system.
- Benefits to investor-owned utilities might be possible if it is evident that investment opportunities are possible with the development of the renewable energy sources and the associated transmission.
- How much renewable energy can be fast-tracked?

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently going through an approval process. The first deliverable, Draft List of Transmission Options Report was submitted to the Commission Project Manager on January 27, 2003 for review and comments.

PROJECT 1.2 NEW WIND SITE ID AND QUALIFICATION

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: Distributed Generation Systems, Inc.

Project Amount: \$351,750

Match Funding: \$ 95,625

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Dale Osborn
(303) 674-2551

Commission Project Manager: Valentino Tiangco, Ph.D.
(916) 654-4664

Commission Technical Lead: Michael Kane (916) 654-7119

Project Description: The purpose of this project is to focus on the identification of new, and developable, wind energy

generation sites in California and neighboring states that will have the ability to access the Pacific HVDC Intertie and that may also add value to the generation, and energy storage, capabilities of the Central Valley Project. Hetch Hetchy/SFPUC/PRP will identify the potential for the development of wind resources that would benefit from the HVDC intertie and synergies between the development of these renewable resources and planned or potential natural gas generation near the HVDC intertie. Sites not in proximity to the HVDC line will also be explored. Hetch Hetchy/SFPUC/PRP will also develop an evaluation of potential synergies between wind resource locations and existing planned or potential natural gas plant developments and storage opportunities associated with Western Area Power Administration's (WAPA) Central Valley Project. This assessment of wind resources will build on existing resource maps.

The specific objective of this project is:

- Identify and quantify the potential sites, including a ranking of the sites based on project economics. It is expected that at least twenty (20) developable sites will be identified. However, the size of the projects required to support the cost of interconnection to the HVDC Intertie will limit the number of such sites.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system;
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- Over 2000 MW of new renewable generation to supply California
- Corresponding reduction in fuel price risk
- Offsetting emissions from traditional power generating stations
- Increased utilization of existing transmission assets
- Economic development activity in excess of \$4,000,000,000
- Number of developable sites identified
- Total capacity of identified sites
- Competitive economics of each site
- Synergies with storage, HVDC Intertie and Central Valley Project

- Usefulness to PRP members

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently going through an approval process.

PROJECT 1.3 NEW GEOTHERMAL RESOURCE ASSESSMENT

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: GeothermEx

Project Amount: \$303,458

Match Funding: \$200,000

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Subir Sanyal
(510) 527-9876

Commission Project Manager: Valentino Tiangco, Ph.D.
(916) 654-4664

Commission Technical Lead: Gail Wigget, Ph.D.
(916) 653-7551

Project Description: The purpose of this project is to identify the potential for the development of geothermal resources that would benefit from the HVDC intertie and synergies between the development of these renewable resources and planned or potential natural gas generation near the HVDC intertie. Hetch Hetchy/SFPUC/PRP will also develop a detailed statewide assessment of geothermal resources and an evaluation of potential synergies between geothermal resource locations and existing planned or potential natural gas plant developments. The resource assessment will build on existing resource maps.

The specific objective of this project is to provide a portfolio of well-characterized geothermal resources located within approximately 50 miles of the HVDC Intertie, thus promoting the development of new geothermal power projects and/or an increase in the generating capacity at existing geothermal projects. This will be accomplished by characterizing and quantifying each resource in terms of its minimum and most-likely generating capacity, determining and estimating the costs of exploration and/or development required to reach those capacities, and calculating the associated total development costs and unit development cost (\$/kW installed). The development cost will include transmission tie-in costs, as determined by other participants in this project.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse

electricity system;

- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- Increase the amount of geothermal generation in California by bringing new resources on line or adding capacity at existing resources.
- Increase in the level of interest and activity in geothermal exploration. The current energy situation in the west has already caused increased interest in the expansion, sale or purchase of existing geothermal facilities
- Increase the affordability of geothermal projects by minimizing transmission costs.
- Increase in generation capacity within 50 miles of the HVDC intertie due to the results of implementing this project are 300 MW, 600 MW and 900 MW within 5 years, 10 years and 15 years, respectively.

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently going through an approval process. Preliminary database structure in Microsoft Access has been started to generate the first deliverable in this project, Geothermal Resource Database.

Emphasis Area 2: Increasing Affordability of Existing Renewable Energy Facilities

PROJECT 2.1 UPGRADING EXISTING GEOTHERMAL SITES

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: GeothermEx

Project Amount: \$204,411

Match Funding: \$ 0

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Subir Sanyal
(510) 527-9876

Commission Project Manager: Valentino Tiangco, Ph.D.
(916) 654-4664

Commission Technical Lead: Pablo Gutierrez (916) 654-4663

Project Description: The purpose of this project is to assess the prospects of improving the output of each of the 43 existing geothermal facilities in California, including consideration of improving access to the geothermal resources as well as improving the design and operation of the power plants.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system;
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- Increase the amount of geothermal utilization in California that is achievable without any exploration or new development risk.
- A set of improvements in resource supply and/or surface facilities that could lead to extra generation from many of the existing power plants for a unit cost below that of developing a new geothermal power project.
- Increase in generation on the order of 10% may be achieved from the existing facilities, followed by another 10% over the following 5 years. Given the existing plants' total capacity of 2,400 MW, a 240 MW increase in capacity in 5 years and a total increase of 480 MW within 10 years appear reasonable.

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently going through an approval process.

Emphasis Area 3: Expanding Affordability and Diversity Using Renewable Distributed Generation

PROJECT 3.1 DISTRIBUTED GENERATION ASSESSMENT

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: Energy and Environmental Economics, Inc.(E3)

Project Amount: \$590,600

Match Funding: \$84,780

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Snuller Price
(415) 391-5100

Commission Project Manager: Valentino Tiangco, Ph.D.
(916) 654-4664

Commission Technical Lead: Prab Sethi, P.E. (916) 654-4509

Project Description: The purpose of this project will identify the best locations for distributed generation in local utility distribution systems, including reliability impacts in the analysis, and to assess the impact of load growth and generator

uncertainty on the results. The analysis will focus on four distribution systems including systems for the City of Palo Alto Utilities (CPAU), the City of Alameda as well as two others among the PRP member utilities. The overall objective is to accelerate the deployment of renewable energy systems in a distributed generation mode by fully accounting for all benefits.

Contractor will identify at least three potential locations in each system. Reliability impacts will be expressed using estimated incremental changes to expected unserved energy (EUE). Reliability financial value will be expressed using both direct utility distribution company (UDC) cost savings and incremental customer value-of-service (VOS) estimates.

This project includes both distribution engineering and economic analysis components. E3 will complete the economic analysis and Electrotek Concepts as subcontractor to E3 will complete the engineering analysis.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system;
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- Within five-years this project aims to make available a comprehensive and carefully thought-out approach for evaluating the local distribution systems for the best placement of renewable generation resources.
- Within ten-years this approach will be refined by member and other utilities to become standard industry practice.
- Within fifteen-years this standard practice will have been in place long enough to improve efficiency in distribution systems state- and nation-wide. This will lead to increased opportunities for renewable generation because of the higher value they receive as well as the decrease in costs of utility delivery systems.

Performance metrics that represent a quantifiable or measurable result from this project work include:

- Timely reports and presentations.
- Successful identification of value reflected by feeder. The analysis may find that there are many, or possibly few cost-effective distributed generation opportunities.

- Work completed on time and under budget.
- Results and work quality to the satisfaction of the distribution company, Technical Advisors and the Commission.

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently going through an approval process.

PROJECT 3.2 BIOMASS PROJECT DISTRIBUTED GENERATION VALUE ANALYSIS

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: McNeil Technologies

Project Amount: \$729,569

Match Funding: \$400,000

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Kevin Degroat (703) 921-1632

Commission Project Manager: Valentino Tiangco, Ph.D. (916) 654-4664

Commission Technical Lead: Prab Sethi, P.E. (916) 654-4509

Project Description: The purpose of this project is to pursue the development and deployment of small modular biomass systems for distributed generation (DG) applications within the service territory of public power utilities. The project will initially focus on conducting research within the territory of the Truckee Donner Public Utility District (TDPUD) as a test case. Based on the results, the analytic approach will then be modified and expanded to other public power utilities. The primary technology focus will be small, modular biomass energy generators in the following applications:

- Microgeneration – 15 – 50 kW systems deployed at load centers with net metering capability
- Small Generation - 1-10 MW systems generating power for sale to wholesale or retail markets, either as stand-alone plants or in combination with pumped storage or other fossil fuel hybrids.

The primary fuel resource to be targeted is biomass generated from small trees removed during forest restoration and wildfire threat reduction operations. Due to the high costs associated with harvesting and transporting this material, the ability to locate biomass generation close to the supply may yield benefits to both the utility system and the public. Potential benefits include deferred or avoided T&D system upgrades, better local reliability and power quality, fuel supply diversity, improvements in air quality from reduced or avoided emissions, and the value of reducing wildfire hazards by thinning forest areas to generate biomass power.

The objectives of the project are to:

- Determine the appropriate performance characteristics (utility system needs, technology, size and cost) and most suitable locations for small modular biomass generators to provide high strategic value to the electricity system, while simultaneously providing high public benefits;
- Conduct a technology demonstration project in the 15 – 50 kWe range;
- Perform detailed engineering/economic studies of biomass plants in the 1 – 10 MW range; and
- Develop data and models that can be used to document the results and apply similar techniques in other regions of the state.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system.
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions.
- Enhancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- Demonstrate the economic and public benefits of using biomass resources that are largely wasted today.
- Demonstrate the value of deploying modular biomass systems strategically within the electric transmission and distribution system to enhance its benefits.
- Lead to the development of a modular biomass generating plant that will demonstrate both the technology and a new marketing approach for siting systems, that other electric service providers and developers will be able to apply.

The key performance metrics that can be used to measure the success of the project are:

- Commission and peer acceptance of the analysis tools and methods used to characterize distributed generation opportunities and benefits of biomass generation.
- Demonstrate of a small modular biomass technology in a grid-connected setting (approximate size 15 kWe). The system will generate power for the on-site load, for export back to the grid, and for a combination of on-site and grid export.
- Reduce BioMax costs of generation by 25 percent over current state of the art.
- Develop of a small generating plant (1-10 MW) in size by

TenderLand (pending favorable economic and technical analysis).

- Successful adaptation of modular biomass generating technology, controls and operating procedures identified during the analysis to enhance the distribution generation value of projects.
- Acceptance by consumers, TenderLand, Truckee Donner or one other public power entity of the technical, business and marketing plans for the project.
- Public recognition in newspapers and other media outlets of the public benefits produced by the project.

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently going through an approval process.

Emphasis Area 4: Developing Renewable Energy Technologies for Tomorrow's Electricity System

PROJECT 4.1 SOLAR THERMAL PARABOLIC TROUGH POWERPLANT

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: Duke Solar

Project Amount: \$630,804

Match Funding: \$157,701

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Gilbert Cohen

(919) 871-0423

Commission Project Manager: Valentino Tiangco, Ph.D.

(916) 654-4664

Commission Technical Lead: George Simons

(916) 654-4659

Project Description: The purpose of this project is to perform a pre-feasibility evaluation of advanced solar thermal power plants that will lead to an aggregated Power Purchase Agreement (PPA) from a group of California municipal utility companies. The plants, to be developed as IPP projects subsequent to the completion of this effort, are to consist of a series of advanced parabolic trough solar thermal power facilities at California sites totaling 1000 MWe, with emphasis on supply to the Pacific HVDC intertie. The future plants would be built in time-sequenced phases, each consisting of a single or complex of plants from 50 to 200 MW in size. A key objective of this evaluation will be to determine the optimum approach for development.

The technical objectives of this project are to:

- evaluate advanced solar field and system configuration

- concepts suitable for imminent commercial implementation,
- determine the required power capacities and production schedule to contribute to aggregated system demand requirements using dispatchable solar thermal power plants,
- identify the optimal and alternative sites for the selected solar thermal power plant facilities, and
- evaluate the prospect of interconnection to the Pacific HVDC intertie in the Owens Valley/Mojave Desert corridor in particular.

The economic objectives of this project are to:

- review available system benefit charges, subsidies, production credits, green power premiums, and other renewable incentives,
- evaluate all siting requirements and establish appropriate financial assumptions,
- perform initial cost, performance, and economic analyses of promising solar thermal power plant options and configurations,
- establish schedule for plant design, construction and operation,
- explore various business and ownership models, and
- develop, working with the Muni's, a draft PPA for implementation.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system;
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- Deliver new site selection data for California for large-scale solar thermal power plants near the Pacific HVDC intertie or elsewhere.
- Propose a construction plan for a sequence of plants up to a total of 1000 MW.
- Show the performance and cost reductions that may be derived from a next series of projects, develop a new PPA model for large-scale solar thermal power plants.

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently

going through an approval process.

PROJECT 4.2 HYBRID BIOFUEL/NATURAL GAS

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: Stirling Energy Systems, Inc.

Project Amount: \$525,000

Match Funding: \$174,999

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Steve Levine

(602) 957-1818

Commission Project Manager: Valentino Tiangco, Ph.D.

(916) 654-4664

Commission Technical Lead: Valentino Tiangco, Ph.D. (916)

654-4664

Project Description: The purpose of this project is to focus on the development of bio-fueled and natural gas cofired modular Stirling engine systems for distributed and on-site generation applications. The objectives of this project are to complete research and development for a demonstration prototype dual-fueled, bio and natural gas, Stirling engine(s) generator set. This system will have a generating capacity of approximately (90) kilowatts capable of operating in accordance with California and Federal interconnection and emissions standards and further to establish parameters (technical and economic) for successful commercialization of the dual fuel prototype(s).

Preferred fuels are expected to be biogas from wastewater treatment plant flare off-gas and landfill gas. For solid waste and high sulfur-content biogas fuels, 2-stage burners may be required. For larger output systems, gas processing may be required or economically advantageous. At a minimum, the fuels that will be tested include, landfill gas and natural gas.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system;
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- Develop a modified external burner section capable of operating on available bio-fuels within program design and

economic parameters.

- Integrate the modified external burner section with a Stirling engine with a generating capacity of approximately 90 kilowatts for use as an on-site distribution generation demonstration prototype unit.
- Field Test the prototype/demonstration unit
- Establish economic model for markets conditions with respect to price competitiveness (as compared to other green options, incentive driven, blended green offerings). Low production price target is \$1500 per installed kWh, \$400 mass production scale. These numbers are conservatively consistent with the NASA Mod II report for natural gas fired systems.
- Financial and business model for product offering in California market (5 year, 10, year) roll out. Goal is to achieve results capable of attracting a strategic co-investor, production vendors and distributors. This would avoid additional substantial funding by PIER.
- Establish teaming agreements for product/systems with PPREAT members and partners, prospective co-investors, vendors and distributors.
- Projected Alpha commercial unit has a target date of 12/31/02.
- Projected installed units approximately (10) units and (1) MW by 12/31/03
- Projected (10) MW installed at year (5)
- Projected (50) MW installed by year (10)
- Projected (250) MW installed by year (15)

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently going through an approval process.

PROJECT 4.3 ENERGY STORAGE FOR RENEWABLE GENERATION

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: Electranix Corporation

Project Amount: \$318,728

Match Funding: \$82,837

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Dennis Woodford (204) 953-1832

Commission Project Manager: Valentino Tiangco, Ph.D. (916) 654-4664

Commission Technical Lead: Elaine Sison-Lebrilla (916) 653-0363

Project Description: The purpose of this project is to address how the application of energy storage capability might increase

the economic effectiveness and value of wind and PV renewable energy sources. A particular focus will be placed on potential interactions with the HVDC inertia project, but the methods used will also apply to other possible development locations. In specific terms, the project will look at:

- Realistic, available energy storage options that will be quantified in terms of their cost effectiveness. Those energy storage options that are not cost effective will be discarded.
- The energy storage options that will be considered will include but not be limited to the following:
 - Existing hydroelectric resources
 - Batteries
 - Superconducting magnetic energy storage
 - Regenerative fuel cells
- Sizing and location of new energy storage facilities if they are cost effective.
- Possible hydroelectric generating companies that might be amenable to a contract for energy storage.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system;
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- A corresponding amount of less environmentally friendly energy will be displaced.
- Energy prices in California could be stabilized due to additional generation. Non-volatile energy pricing will be possible from the identified renewable energy sources, with a stabilizing effect on overall electric energy pricing in California.
- Added energy from the development of renewable resources with energy storage will increase the reliability of energy supply to the California power system.
- Provide a technical assessment on the energy storage options for the renewable energy resources identified for future development in the California -Nevada border regions.
- Economic viability will also be determined for the various energy storage options and recommendations for future developments will be made. Such recommendations cannot

be forthcoming at this stage unless this project is completed.

- A profitable case made by this project for use of energy storage in conjunction with renewable energy sources will open up the way for a schedule of development as laid out below.

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract is currently going through an approval process.

Emphasis Area 5: Integrating Program Findings To Ensure Broad Replicability

PROJECT 5.1 INTEGRATING PROGRAM FINDINGS TO ENSURE BROAD REPLICABILITY

Contract #: 500-01-042

Contractor: Hetch Hetchy Water and Power/SF PUC

Subcontractor: Center for Resources Solutions

Project Amount: \$508,033

Match Funding: \$40,643

Contract Project Manager: Fred Weiner (415) 554-3185

Subcontractor Project Manager: Ray Dracker
(415) 561-2135

Commission Project Manager: Valentino Tiangco, Ph.D.
(916) 654-4664

Commission Technical Lead: Valentino Tiangco, Ph.D. (916)
654-4664

Project Description: The purpose of this project is to ensure that the technical findings of this research and development effort are integrated with one another and delivered to PRP electricity service providers such as Hetch Hetchy/SF PUC that can best utilize the work in their ongoing program efforts.

The technical objectives of this project are to:

- Maximize the value and impacts of the HVDC Intertie assessment by integrating the resource assessment and project planning work in the Bulk Power tasks. There is a large quantity of commercial-quality wind, solar and geothermal resource close to the HVDC line in Oregon, Nevada and California. It is expected that a large (500 MW – 2000 MW) tap will be required to ensure cost effectiveness.
- Furthermore, it will be critical to have a portfolio of project options to feed into the Line to provide for an optimal loading (mixing the right quantities of wind and solar, which have complimentary seasonal and diurnal production profiles, with some dispatchable geothermal, will be critical to overall economic viability). The integrated output of a multi-component renewable energy mega-project will need to fit into the existing seasonal and daily load on the Line.

The economic/business objectives of this project are to:

- Feed resource, cost, and other project or technology specific PIER Project results into the on-going Hetch Hetchy/SFPUC/PRP utility resource and project planning activities. PRP member PV initiatives, other distributed generation initiatives, and bulk renewable RFP initiatives are underway and are expected to gain momentum throughout the course of this PIER Program. Feeding the economic and business results of this Program directly into the utility planning and procurement processes will ensure high quality renewable energy implementation.

This Project supports the PIER Program objective of:

- Improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system;
- Improving environmental and public health costs/risks from California's electricity system by developing clean renewable energy technologies that have no air polluting emissions; and
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

Proposed Outcomes:

- Economically-viable HVDC/Bulk Renewables project combination.
- Integrated distributed generation assessment resulting to successful demonstration and deployment

Project Status:

The project is ongoing. Technical kickoff meeting was held on October 30, 2002 in Sacramento. The subcontract has been signed and executed.

The draft bulk power integration design criteria workshop was submitted for review and comments. Initial key findings about this report includes:

- Analysis should evaluate both AC and DG transmission options near large-scale renewable resources.
- Likely expenditures for interconnection (on the order of \$125 million) will require a substantial capacity addition (for example, 1000MW of wind capacity) to justify investment.
- Consideration should be given to resource loading factors. Wind and solar capacity alone are poor candidates for justifying new or upgraded transmission since they only require the transmission capacity for a portion of the time. Geothermal is a good candidate since it is a baseload resource. A potential strategy is to focus transmission plans on new geothermal resource, then adjust sizing to include

solar and wind resources in the same region.

- Alternatively, power projects dominated by wind or solar could be complimented by dispatchable northern hydro power or energy storage to create an optimal production profile for the transmission system.
- Pacific DC Intertie business issues (commitments, contracts and regulatory) need to be considered in connection with technical and economic issues
- Northern Nevada is dominated by geothermal and wind resource potential. Southern Nevada is dominated by solar resource, with some wind resource potential

Implementation of the renewable portfolio standard will be a key variable in renewable resource and transmission planning. Public power commitments to renewable resource procurement will be highly influenced by interpretation of legislative requirements and by yet-to-be-determined policy mechanisms to make transmission capacity available for renewables on a preferred or expedited basis.

The first distributed generation integration workshop will be held in March 2003.



Wind Turbine Company EMD Turbines**Contract #:** 500-00-019**Contractor:** Wind Turbine Co.**Contract amount:** \$1,300,000**Contractor Project Manager:** Doug Jung (707) 523-4585**Commission Contract Manager:** Michael Kane
(916) 654-7119

Project Description: The purpose of this project is to transition to Phase II in the development and demonstration of a cost effective, next generation wind turbine capable of producing electricity at prices that can compete with conventional electricity generation systems (fossil fuel, natural gas). The objectives are to develop and to test a lower cost, grid-connected, 500kW commercially viable wind turbine (EMD) scalable to 750kW at a California site. The site has been identified as the Fairmont wind site located in Southern California. During Phase I of the project funded under a previous contract (500-97-032), a prototype version of the innovative turbine was successfully designed, developed and demonstrated at the National Renewable Energy Laboratory (NREL) test facility in Colorado.

The 250kW prototype (POC) is a horizontal-axis, 2-bladed, downwind turbine and has amassed over 1000 hrs in operation in attended and unattended production mode combined. The POC remains a valuable development and test platform for new modifications and turbine studies. Leveraging off the successes and lessons learned from the POC, realizing the cost saving benefits of the innovative lightweight design, and flap-motion control mechanism will be further enhanced and demonstrated using the EMD in typical California Class 5 to Class 6 wind conditions (approximately 13-20 mph). The goal is to develop and test the 2-bladed, horizontal-axis system at 500kW and scale up to 750kW. The machine will be suited for both grid-connected and for standalone applications in combination with other generation and energy storage options.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing a lower cost wind turbine capable of producing electricity at prices that can compete with conventional electricity generation;
- Improving the environment, public health and safety of California's electrical system by promoting "zero" emissions electricity generation using alternative energy solutions and by reducing air pollution and global warming;
- Improving electricity reliability/quality/sufficiency by using a generation capability to reduce dependence on fossil fuel resources and improving "free" fuel resources as protection from fuel price volatility;
- Strengthening the California economy by bringing advance

wind turbine technology that will require a multi-disciplinary pool of engineers, support personnel to the industry; and

- Providing greater choices for California consumers by advancing and making available more dependable green energy alternatives.

Proposed outcomes:

- Bring to market readiness a commercially viable and competitive turbine.
- Provide electrical power to the California grid.
- Produce a fuel generation system to provide reliable and cost competitive "free" and "clean" energy alternatives to consumers.
- Advance turbine design and manufacturing with an innovative lightweight, flexible design to reduce structural loads and improve turbine reliability and service life.
- Put California back into the spotlight as a leader in wind energy resources.
- Bring wind turbine technology and know how back to California and to the U.S. by advancing the technology, improving the workforce and creating new job opportunities.

Project Status:

The 500kW EMD has been installed at a site near Lancaster, California. The turbine experienced a tower-blade strike after approximately 70 hours of operation, damaging one of the blades. Both blades were removed and shipped to NREL for testing to determine cause of the incident. Based on the NREL findings, control and protection software has been upgraded to prevent additional strikes. The EMD-1 is to be refitted with a pair of off-the-shelf blades, and is scheduled to resume operation in February 2003. Design work continues on the EMD-2, the 750 kW follow-on to EMD-1. Work to date has concentrated on flap motion restraint refinement and advanced control systems. The project is still expected to meet all technical objectives for EMD-1 and to supply a complete design for EMD-2.

California Wind Energy Consortium**Contract #:** 500-00-029**Contractor:** University of California, Davis**Contract amount:** \$330,000**Contractor Project Manager:** Bob Richardson (530) 474-4819**Commission Contract Manager:** Elaine Sison-Lebrilla/Dora Yen (916) 653-4128

Project Description: The purpose of this project is to provide the initial impetus for establishing a wind energy forum or consortium of parties, and the recognition that is needed at the state level. Based on input from the wind industry, the PIER

program has determined a need to establish a focal center at the state level to allow coordination of diverse parties to further develop, enhance and address the needs of the wind industry in California. The mission of the consortium is to support the development of safe, reliable, environmentally sound and affordable wind electric generation capacity for the State. To fulfill this mission, the Consortium will administer a focused, statewide program of research, technology development, deployment and technical excellence. These efforts will be conducted in close cooperation with the Commission PIER program, industry, state and federal agencies, and other institutions to maximize the benefits of wind energy resources in California.

Consortium members will include representatives from the wind industry, Energy Commission staff involved in wind energy development, U. S. DOE/NREL staff, members of the environmental community, and representatives from the academic and research community conducting wind energy research. One of the main goals of this project is to establish and plan the self-sustaining efforts of the California Wind Energy Consortium. Ultimately, the consortium will provide expertise to the Commission to help supplement and enhance wind energy planning and development programs specific to California.

In addition, the consortium has a goal to:

- Support the existing wind industry by maintaining a wind performance database;
- Develop a wind energy technician training plan;
- Prepare investigative white papers reporting on current industry issues and research scenarios; and
- Assist in the development of a state wind anemometer loan program plan.

This project supports the PIER Program objectives of:

- Improving electricity reliability/quality/sufficiency of California's electricity by:
 - a) ensuring California maintains a competent and current wind energy support base.
 - b) providing immediate expertise to PIER planning activities in areas pertaining to wind energy technology from design, operation/maintenance, electrical generation and management.
 - c) providing immediate expertise to evaluate and assess electricity reliability in emergency scenarios;
- Strengthening the California economy by properly target efforts and channel funds to focus on California related issues such as complex topography; and creating new jobs/position and training new technicians and engineers to support the wind industry; and

- Providing greater choices for California energy consumers by providing current, reliable facts on the wind industry, dispel myths about wind energy, and provide better understanding of the wind industry's capabilities by combining energy resources through case studies and optimization scenarios.

Proposed Outcomes:

- Establish the California Wind Energy Consortium as a forum for a coordinated approach to developing wind energy systems beneficial to California's unique needs.
- Provide plans and guidelines for a statewide wind-engineering technician-training program to ensure California maintains a competent support base.
- Release investigative white papers that offer plausible approaches to optimizing wind plant facilities including transmission infrastructure issues.
- Integrate and optimize wind with other generation systems and storage systems and wind speed and power trends.
- Assist in planning for a state wind anemometer loan program and personnel to support the effort.
- Continuing and enhancing the reporting efforts of the Wind Project Performance Reporting System (WPRS).
- Support consumer education efforts by clarifying wind turbine facts and fiction.

Project Status:

To date the California Wind Energy Consortium has:

- Established an office on the UC Davis campus in the first quarter of 2002 which is currently serving as a focal center for wind energy related developments in the state.
- Established and held semi-annual meetings of an advisory board of academics, wind industry professionals and governmental policy personnel during its first year,
- Hosted the Wind Industry Forum in December of 2002, which was well received by the attendees.
- Supported, maintained and proposed improvements on the current Wind Performance Reporting System (WPRS), and developed an electronic WPRS that it posted to its web site.
- Completed one of four scenario-based white papers, *Wind Speed and Electric Power Trends* for the Tehachapi wind resource area has been completed, and two others are nearing completion.
- Established a Wind Anemometer Loan Program that is approximately 80% complete.
- Planned for a follow-on contract to extend the Consortium for the 2003/2004 fiscal year.
- Provided information regarding the California Wind Energy Consortium. The electronic WPRS and Wind Forum proceedings can be found at <http://cwec.ucdavis.edu>.

Strategic Value Analysis: GIS Development**Contract #:** 500-00-030**Contractor:** California Department of Forestry**Contract amount:** \$280,000**Contractor Project Manager:** Boris Glezer (858) 481-5977**Commission Contract Manager:** Prab Sethi (916) 654-4509

Project Description: The purpose of this contract is to supplement an existing Geographic Information System (GIS) developed and operated by the California Department of Forestry (CDF) to help identify strategic locations for using renewable energy distributed generation (DG) systems. To accomplish this goal, CDF will do the following:

- Analyze existing spatial information related to energy use, environmental and demographic characteristics of sub-regions within the state
- Create required data layers on available renewable energy resources, and
- Use data on problem areas within California's electricity system developed by another contract (500-00-031).

As a result, this contract will identify areas where renewable DG systems can potentially help address electricity reliability, congestion and power quality problems. At the same time, this contract will provide public benefits such as improving air quality, preventing wildfires in high-risk areas, and increasing employment in economically stressed areas of the state.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by identifying where renewable distributed generation systems can be located to help alleviate transmission and distribution capacity and congestion problems in the state.

Proposed Outcomes:

- Collect data sets necessary to create thematic layers on renewable energy resources within California, layers on detailed demographic, environmental, and energy use information, and layers that incorporate the results from the McNeil Technologies (500-00-031) power flow analysis.
- Construct thematic layers and develop methods for running iterative scenarios that help determine optimal locations for renewable generating systems that provide strategic benefit to California's electricity system as well as high public benefits that extend beyond impacts to the electricity system.
- Develop a windows based program (or equivalent process) that enables staff in the PIER Renewables program to remotely access the GIS information, run different and new scenarios based on new data, and collect the associated results.

- Assist in establishing at least two case studies that provide representative and site-specific analyses on the use of renewable distributed generation systems to effectively and affordably address California electricity system problems.
- Provide a written report and GIS-based maps depicting the key results obtained from the various GIS scenarios, and the two case studies. The key results will include identification of the optimal locations where renewable generation systems can possibly provide strategic benefit to California's electricity system as well as high public benefits.

Project Status:

Work is progressing in the identification, collection and development of information for GIS model and mapping

Strategic Value Analysis: Power Flow Simulations and Development of Renewable RD&D Performance Goals**Contract #:** 500-00-031**Contractor:** McNeil Technologies**Subcontractors:** Davis Power Consulting:**Contract amount:** \$730,000**Contractor Project Manager:** Scott Haase (303) 980-1969**Commission Contract Manager:** Prab Sethi (916) 654-4509

Project Description: The purpose of this contract is to investigate the extent to which renewable distributed electricity generation systems can address current and future problems facing California's electricity system while simultaneously providing other high public benefits. This project will help determine the necessary performance, cost characteristics, and the best locations for the renewable power technologies that will best provide the combined high electricity system and public benefits to California. A combination of power flow models and GIS tools will be used to identify the ability of renewable generation systems to address electricity system problems and identify the optimal locations for using renewable generation systems.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electrical system by identifying where renewable distributed generation systems can be located to best help alleviate transmission and distribution capacity and congestion problems in the state.

Proposed Outcomes:

- Identify and characterize generation and transmission and distribution (T&D) problems confronting California's electricity system over the next 5 and 10 years using power

flow models calibrated to California's electricity system and based on various demand scenarios

- Determine the performance characteristics of generation, distribution, transmission and substation upgrades or expansions needed to effectively address electricity system problems over the next 5 and 10 years as identified in the power flow models
- Identify locations within California's electricity system where sufficient renewable generation supplies exist to effectively address electricity system "hot spots" as identified in the power flow models and the GIS results obtained from an associated contract
- Establish at least 2 case studies that provide representative and site specific analyses on the use of renewable generation systems to effectively and affordably address California's electricity system problems, while simultaneously providing other high public benefits; and
- Specify PIER renewable energy research and development goals that act as targets for the required performance and cost characteristics that will enable advanced renewable generation systems to help address the problems facing California's electricity system.

Project Status:

Work is progressing for developing datasets for power flow modeling of California's electricity system and power flow model simulations of California's hot spots.

SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)

Contract #: 500-00-034

Contractor: Sacramento Municipal Utility District

Contract amount: \$13,649,499

Match amount: \$10,549,413

Contractor Project Manager: Sid Bhatt (650) 855-8751

Commission Contract Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe, 916-654-4412

Project Description: The purpose of this contract is to co-fund nineteen research, development and demonstration (RD&D) projects that will make renewable energy technologies part of a more affordable and diverse electricity system in California over the next 5, 10 and 15 years. The Sacramento Municipal Utility District (SMUD) is administering the project. The intent is to develop effective partnerships between market-oriented electricity suppliers (SMUD) and renewable energy technology developers. The combination of market-oriented prime contractors directing the development activities of technology experts provides a high likelihood of successful market adoption of advanced renewable energy services and products.

Over the past several years, SMUD has demonstrated a national leadership role in photovoltaics (PV) 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 SMUD program expands its PV focus to include wind and biomass resources available in the SMUD territory. Fourteen of the nineteen projects concentrate on photovoltaics (PV) technologies and markets. The SMUD PV projects include the following:

- Advanced PV mounting systems that will enable PV systems to be more easily and cost effectively installed on a variety of roof types, while still employing a structured manufacturing and installation approach. This effort will significantly expand the number of customers who can employ PV systems to help meet their electricity needs.
- Building integrated PV technologies are being developed that will increase the value of PV systems to customers by combining energy efficiency features, an extended roof life and electricity generating capabilities into a single system package.
- Using PV in combination with advanced space cooling systems in ways that enable electricity customers to meet all their cooling needs during California's hot summer peak times.
- Strategies and analytical tools for developing future PV systems that directly benefit electricity customers, while also generating significant system-wide cost savings by deferring expensive transmission and distribution upgrades or expansions.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by making renewable energy technologies part of a more affordable and diverse electricity system;
- Improving the reliability/quality of California's electrical system by accelerating the development of renewable distributed generation systems in high-need areas of the state; and
- Providing greater choices for California consumers by increasing the use of renewable energy technologies in California's electricity mix.

In addition to its advanced PV projects, the SMUD program also involves development of innovative biomass, wind, and concentrating solar electricity systems. Projects include:

- Biomass work by SMUD that follows an earlier funded California Energy Commission project by Yolo County. This project emphasizes increasing the affordability of electricity

generated from landfill gas. Using special landfill designs and operating techniques, Yolo County successfully demonstrated a way to accelerate the decomposition of organic materials in landfill control cells, resulting in a three-fold increase in landfill gas. This method of using landfills as biological reactors significantly increases the cost-effectiveness of generating electricity from California landfills. The SMUD project at Yolo County will extend Yolo County's earlier work on accelerated decomposition to a full-scale landfill and help bring this technology into the marketplace. With over 300 active landfills in California, the accelerated decomposition approach could help considerably increase our ability to use landfill gas to generate more affordable electricity.

- Investigating ways to enhance use of wind resources to help make electricity more affordable and diverse. Under a subcontract to Dehlsen Associates, SMUD will develop and test a commercial-scale 1.5-megawatt wind turbine geartrain composed of a series of small, parallel gearboxes and generators. By distributing the geartrain components, Dehlsen can lessen the amount of torque (and therefore stress) applied to any one part of the geartrain. This means less overbuilding of geartrains, which in turn means lower geartrain capital costs. In addition, lower stress means lower maintenance costs. Overall, Dehlsen expects the new geartrain to cost forty percent less than presently available geartrains.
- Science Applications International Corporation (SAIC) will develop and demonstrate a 20-25 kW concentrating solar dish/Stirling system and a concentrating solar dish/photovoltaic system that can generate more electricity per square foot of collection area and may better address industrial electricity needs. NREL believes that a PV concentrating system currently can achieve eighteen percent solar-to-electrical power efficiency and, in the next few years, can achieve efficiencies exceeding thirty percent. The higher power efficiencies will make it possible for industrial users to harness solar energy to help meet their electricity needs.

Programmatic Project Status:

Extensive review of the program, and the projects from industry experts is ensuring that the projects are proceeding in a positive direction. As of January 2003, two Renewable Programmatic Advisory Committee, and two Critical Project Review meetings have been held with favorable results. An annual review of the programmatic received positive recommendation to proceed from the PIER Research Committee.

All projects have signed sub-contracts, held kickoff meetings, and are proceeding with RD&D activities except for the Oakridge National Laboratories Hybrid Lighting demonstration

project (#4.4), scheduled for installation in 2004.

Some projects are finishing in early 2003, while the Utility System Capacity and Customer Demand Value of PV by NREL (#1.3) is already completed.

Public and private web based project information is available at www.smud.org/pier

The list of projects by emphasis area are listed below:

Emphasis Area 1: Assessing and Targeting Renewable Electricity Development

Project 1.1 Technology Assessment for Advanced Biomass Power Generation

Contract #: 500-00-034

Contractor: SMUD Programmatic-Project # 1.1 UC

Project Amount: \$158,070

Match Funding: \$20,120

Contract Project Manager: Bryan Jenkins 530-752-1422

Commission Project Manager: Elaine Sison-Lebrilla P.E. / Joseph McCabe, 916-654-4412

Commission Technical Lead: Valentino Tiangco 916-654-4664

Project Description: A technical assessment will be conducted of advanced and novel power generation concepts from biomass to increase the efficiency of conversion and improve the opportunities for agricultural and solid waste fuels not currently utilized in California for reasons of ash fouling, emissions, or cost. The assessment will include a literature review and industry survey of facilities and applications throughout the world that will:

- compile of plant design concepts and operating characteristics,
- provide technical and environmental performance, costs, and problems,
- identify fuel types, and
- compare these findings with current technologies in California.

Promising designs and concepts will be identified along with enhancements needed for potential application in the Sacramento region to meet technical and environmental constraints.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by determining the feasibility in the Sacramento region of promising commercial biomass power generation systems

used in Europe and elsewhere, including solid fueled, gasification, liquefaction, and landfill gas technologies; and

- Improving the environment, public health and safety by establishing environmental performance of these novel and advanced biomass technologies for application in the region.

Proposed Outcomes:

- Identify sites, resources, and scales of biomass power generation that might be developed over the near and long term.
- Initiate industry collaborations for concept evaluation

Project Status:

Kickoff meeting was held in 2002. Project is on-going.

Project 1.2 Photovoltaic Markets and Technologies

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 1.2 SEPA

Project Amount: \$316,376

Match Funding: \$0

Contract Project Manager: Stephen L. Hester 202-457-0868

Commission Project Manager: Elaine Sison-Lebrilla P.E / Joseph McCabe, 916-654-4412

Commission Technical Lead: Joseph McCabe 916-654-4412

Project Description: Use national TEAM-UP and PV industry technical and market knowledge to assess PV project goals and plans. Analyze and recommend the next phase of commercialization for energy service providers like SMUD that have established a successful solar energy market position in their region with significant customer interest in solar energy.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by obtaining the best technical and market input to the planning and setting of initial goals of PV projects in this program; and
- Improving electricity reliability, quality, and sufficiency by developing the next options for solar energy market expansion in the SMUD region.

Proposed Outcomes:

- The overall goal is to have this CEC program benefit from the \$75 million TEAM-UP business model and hardware deployment program funded by the U.S. Department of Energy.

Project Status:

Project is on-going. A group of industry experts have been

convened from the SEPA community and have held a Task Force meeting addressing project specific activities.

Project 1.3 Utility System Capacity and Customer Demand Value of PV - NREL

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 1.3 NREL Values

Project Amount: This project is a high level collaboration between federal and state agencies, and is not receiving any PIER funding.

Match Funding: Total Match

Contract Project Manager: Christy Herig 303-384-6546

Commission Project Manager: Elaine Sison-Lebrilla P.E / Joseph McCabe, 916-654-4412

Commission Technical Lead: Joseph McCabe 916-654-4412

Project Description: Photovoltaic systems have load profiles that are driven by available sunlight. The summer peak-period load profiles in Sacramento also track available sunlight and peak outdoor temperatures, although the peak is shifted about two hours into the evening by thermal lag and residential air conditioning. The National Renewable Energy Laboratory has looked at the California effective load carrying capacity (ELCC) for California's utility system as well as several types of customers. The ELCC for California is one of the highest, averaging 60%- 70%. Recent studies have shown that controlling building loads can improve this ELCC to 95%. However, current rate structures do not adequately reward building owners this type of load control. Similarly, current rate structures do not reward the owners of PV systems who orient their PV arrays westward to match the SMUD system peak. A potentially high value of either PV or advanced building control is not realized.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by using geosynchronous orbiting earth satellite (GOES) satellite data, verified by electric meter data, to determine the potential peak and capacity value of PV. Implementing findings of value into SMUD's accounting system, rates office, and business office; and
- Improving the environment, public health and safety by assuming PV installations for various types of customers and analyze the potential benefits from both load factor and power factor manipulation.

Proposed Outcomes:

- Analyze:
 1. PVs unquantified benefits;
 2. PVs match to utility peak; and
 3. The benefits of orienting PV arrays to match PV output with utility demand peaks.

- Beta test the solar load controller developed by the State University of NY.

Project Status:

Project is finished, with no costs to the state. Multiple reports and presentations to SMUD decision-makers have brought awareness of the value of PV to SMUD, including the Director, Jan Shori. It is envisioned that these values will be implemented in the SMUD rates and billing departments.

Project 1.4 Performance Indexing of PV Systems

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 1.4 PV Performance

Project Amount: \$ 250,000

Contract Project Manager: Sandia National Labs Andrew Rosenthal 505-646-1323

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe 916-654-4412

Commission Technical Lead: Joseph McCabe 916-654-4412

Project Description: Develop and implement on SMUD's centralized data base systems an automated monthly PI determination for each PV system interconnected to SMUD's grid based on system meter readings, and daily weather data. An exception report showing non-operating and under-operating systems will be automatically generated once each billing cycle. A year of trial operation and improvement will follow initial implementation.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by forming a reliable basis for calculating total hourly PV generation; and
- Improving the environment, public health and safety by providing comprehensive and current information on operating health of each grid interconnected PV system.

Proposed Outcomes:

- A monthly exception report identifying non- and under-performing systems. A database available to SMUD staff showing health of any queried system for use with customer comments and concerns.

Project Status:

Sandia National Labs has decided to perform this project for no cost. The original funds have been freed to address inadequacies in other project tasks per the programmatic contract.

Project 1.5 Assessment of Worst-Case Weather Conditions

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 1.5 Worst Case Weather

Project Amount: \$27,000

Contract Project Manager: RWL Analytics of Sonoma CA, Eric Swan 707-939-8823

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe 916-654-4412

Commission Technical Lead: Joseph McCabe 916-654-4412

Project Description: Historical weather records will be analyzed to determine worst-case weather conditions for photovoltaic systems and air-conditioning systems. For PV systems, cloudiness from storms and fog will be examined. For cooling systems, a combination of maximum air temperature and humidity will be examined.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by developing data that will ultimately make it possible for PV to be used in mission-critical applications without being connected to the grid; and
- Improving electricity reliability, quality, and sufficiency by developing weather data that can be used to determine the impact of winter weather on the performance of mission-critical PV systems, such as: traffic signals, transportation-related signage, retail signage, rural signage, streetlights, and parking lot lights.

Proposed Outcomes:

- Develop data that will make it possible to correctly size and evaluate renewable-based air-conditioning equipment.
- Develop weather data that can be used to determine the impact of summer weather on the sizing and performance of air-conditioning equipment of various types, including conventional and renewable.

Project Status:

The bidding process has identified a contractor and the project is currently underway.

Emphasis Area 2: Increasing Affordability by Improving Existing Facilities

Project 2.1 - Accelerated Anaerobic Composting for Energy Generation – Yolo County Landfill

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project #2.1 Yolo Bioreactor

Project Amount: \$1,154,250

Match Funding: \$2,753,000

Contract Project Manager: Ramin Yazdani 530-666-8848

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe 916-654-4412

Commission Technical Lead: Zhiqin Zhang, 916-654-4063

Project Description: This project is to provide technical and economics data and solution to the identified permitting condition that pose constraint in the advancement of this technology into the commercialization phase. This will be accomplished through resolving technical issues, regulatory constrains, and demonstrating the environmental and economic benefits of this technology.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by documenting the capital and operations cost of a full-scale bioreactor and determine the economic viability of it commercialization; and
- Improving the environment, public health and safety by acceleration of waste decomposition and leachate treatment to accomplish rapid completion of composting, stabilization and generation of methane to the maximum practical yield.

Proposed Outcomes:

At project completion substantial technical and economics data will be available to the stakeholders, EPA, and State of California regulatory agencies. This will lead to the acceptance and commercialization of this technology throughout the state. As a result of this demonstration project and acceptance of the Bioreactor Landfilling concept by EPA, and the state, many other public and private landfill owners and operators will be able to implement this technology at other sites. The technology is expected to improve the economics of landfill gas to electricity and yield more renewable landfill gas and provide many environmental benefits for nearly all regions in the United States.

Project Status:

The project is currently on schedule and within the budget. A Critical Project Review has obtained positive results from independent technical experts. Successes foreshadowed include earlier and more rapid generation of landfill gas, improved quality of leachate, and reduction of greenhouse gas emissions. Multiple site visits have confirmed the project's activities. Emphasis Area 3: Expanding Affordability And Diversity Using Renewable Distributed Technologies

Project 3.1 Laminate & Batten Roofing System

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 3.1 USSC PV

Roofing

Project Amount: \$1,508,425

Match Funding: \$1,819,061

Contract Project Manager: Dr. Subhendu Guha 248-475-0100

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe 916-654-4412

Commission Technical Lead: Joseph McCabe 916-654-4412

Project Description: UNI-SOLAR will develop an inexpensive, easy and quick to install building integrated photovoltaic roofing system (PV Roof or PVR) which can be applied to any new or existing roof that has a plywood deck, particle board deck or any other type of solid, continuous under-structure. No comparable product exists at this time. The roofing material will be UNI-SOLAR's triple-junction thin-film amorphous product. The laminate and batten PV Roof will be researched and developed using the following process: The necessary hardware will be designed and tested. A new packaging and product-delivery system will be researched and developed. A UL listing will be procured. An initial demonstration phase of five projects will be completed and the projects will be monitored. Other demonstration projects will also be developed but they will not be monitored as part of this project. Installation and operation manuals and videos will be developed, as will a contractor training program.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by creating a low cost, dual function photovoltaics roofing using UNI-SOLAR large area thin film technology; and
- Improving the environment, public health and safety by providing Class A fire rating and UL listing on all UNI-SOLAR building-integrated photovoltaic (BIPV) products. Developing manuals, videos and training program for designers, installers and users

Proposed Outcomes:

Accommodate the widest range of residential and light commercial roofs. Develop fast, easy installation methods. And build an automated laminating/finishing facility to satisfy demand.

Project Status:

Project is underway with major successes to date. Shipping and installation costs have been reduced with the development of an inexpensive reusable spool of laminates. Time-consuming junction boxes have been replaced by quick connects, potted to top or bottom of laminates. Innovative batten enables laminates to be the weather skin of a roof, thus providing additional value from this truly building integrated photovoltaic product. Multiple field trials and demonstration projects are confirming the products reduced costs and increased value. A site visit in

Michigan confirmed the company's commitment to solar electricity with their new 30 MW thin film module production line.

Project 3.2 BIPV Mounting Approaches for New Construction

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 3.2 Schott BIPV

Project Amount: \$99,180

Contract Project Manager: Miles Russell 781-684-6102

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe 916-654-4412

Commission Technical Lead: Joseph McCabe, 916-654-4412

Project Description: Schott Applied Power Corp. (SAPC) will develop and document BIPV mounting approaches for new building construction. In conjunction with SMUD, SAPC will select a specific range of applications and develop specific mounting approaches for the building industry. SAPC will then develop information to be used by architects and designers.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by creating information such as drawings and specifications that can be used by architects, designers and engineers to promote the incorporation of BIPV in new construction; and
- Improving the environment, public health and safety by identifying focus areas and review the functional requirements for selected BIPV mounting approaches.

Proposed Outcomes:

- Greater options in BIPV mounting techniques for California architects and builders.
- Greater awareness and adoption of PV practices by architects and builders.
- Reduced cost of installation.
- Increased use of BIPV in new construction.

Project Status:

Project is under contract, expect activities starting 2003 after other Schott project (#3.4) finishes.

Project 3.3 Mainstreaming PV for Residential Roofs

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 3.3 Residential PowerLight

Project Amount: \$1,500,000

Match Funding: \$2,038,232

Contract Project Manager: Thomas Dinwoodie 510-540-0550

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe 916-654-4412

Commission Technical Lead: Joseph McCabe 916-654-4412

Project Description: PowerLight will develop a new residential PV roofing product, designed for both retrofit and BIPV applications, which meets the CEC goal of affordability. The product is a system of roof tiles with and without PV, with thermal insulating properties which significantly decrease house-cooling loads through a novel, strictly passive, means of roof deck temperature reduction and lowered attic dew points. The product will have a 50-year design life and will increase roof durability. Under this subcontract, PowerLight will carry out advanced design development, improving on first-generation prototypes, building and testing advanced prototypes, and using focus groups for product evaluation. A full-scale demonstration system will be installed and monitored for thermal and electrical performance. Requirements for certifications and code compliance will be fulfilled. A plan for high volume manufacturing will be completed.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by developing a market-ready product that improves upon existing residential PV roofing products in terms of cost, ease and speed of installation, and electrical and thermal performance;
- Improving the environment, public health and safety by adding insulation value of R-50 to the rooftop (both PV and non-PV tiles, which go around the PV array and on the roof's north slope;
- Maintain PV cell temperatures at relatively cool, "rack-mount" levels, unlike other direct-mounted, building-integrated PV products, resulting in 10-18% higher module output; and
- Be certified by Underwriters Laboratories (UL), International Conference of Building Officials (ICBO), and Institute of Electrical and Electronics Engineers (IEEE).

Proposed Outcomes:

- Be designed for retrofit and building-integrated applications, both waterproof assemblies.
- Be simple to install using traditional roofing practices, including waterproofing, and edge, ridge, and eave details. PV modules snap into a pre-engineered mounting system, easily done by one person on a sloped roof surface.
- Integrate electrical wiring and interconnection into the mounting system, which will be accessible after installation.
- Have electricity and thermal performance that could obtain recognition by CEC Title 24.
- Have a 50-year design life and increases roof durability.

Project Status:

Project is underway. First phase of the project is completed with a roll out of PowerLight's new product at the Utility Photovoltaic Experiences conference in Austin Texas, November 2002. This new product is lightweight, ships easier, and can help reflect more light onto modules than previous solutions. It is a flat or sloped roof product.

Project 3.4 Flat Roof Mounting Approaches

Contract #: 500-00-034

Contractor: SMUD Programmatic-3.4 Schott Flat Roofs

Project Amount: \$ 100,450

Match Funding: \$230,000

Contract Project Manager: Miles Russell (781) 684-6102

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe (916) 654-4412

Commission Technical Lead: Joseph McCabe (916) 654-4412

Project Description: Schott Applied Power Corp. (SAPC) will develop a mounting approach for flat roof top installations. SAPC will meet with SMUD to determine necessary design constraints. Next, SAPC will develop and prototype a design. A manufacturing review will be completed after the prototypes have been fabricated. A demonstration array will be constructed to illustrate the completed design.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by developing modules to easily be mounted on a flat rooftop. The ideal design would eliminate the use of additional ballast materials, or numerous penetrations, although engineering and adherence to appropriate codes must temper these factors; and
- Improving electricity reliability, quality, and sufficiency by reviewing the customer requirements for mounting approaches on buildings with flat roofs. Developing and prototyping designs that meet those approaches.

Proposed Outcomes:

The results of this work should facilitate the use of PV technologies in California. The primary proposed outcomes of this work are anticipated to be:

- Greater choice for purchasers of PV systems.
- Reduced cost of installation
- Increased flexibility for deploying PV systems

Project Status:

Project is underway with major successes to date. A Critical Project Review has obtained positive results from independent technical experts. Taller roof jack with dynamic features, lightweight, cost reductions, and more flexible to roof obstacles.

Project 3.5 Optimization of Residential PV Systems

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 3.5 AstroPower Concrete

Project Amount: \$1,127,000

Match Funding: \$1,197,000

Contract Project Manager: Marc Roper (925) 288-0400

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe (916) 654-4412

Commission Technical Lead: Joseph McCabe (916) 654-4412

Project Description: Astro Power will research and develop components and an integrated system design for its packaged residential solar electric power systems optimized for the California market. To accomplish this, Astro Power will research and develop an advanced:

- PV module/laminate product and associated mounting and wiring system;
- Power Conditioning Unit (PCU) for grid-connected PV systems; and
- Low-cost PV system meter appropriate for the new module/laminate, PCU, and system design configuration.

Astro Power will integrate the advanced module/laminate, PCU, and meter elements into a line of packaged residential PV systems. Through these development activities, Astro Power will improve performance, aesthetics, functionality, usability, and reduce consumer cost by approximately 20%.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by researching and developing an advanced, low-cost PV monitoring system that displays real-time "solar fraction" which will:
 - Display the monetary value of the solar electricity the system has generated. Indicating when the solar electric system is selling electricity to the utility. Displaying the status of the battery bank (if applicable).
 - Provide feedback indicating acceptable operation.
 - Record operating data and transmitting data to a remote location for viewing on the Internet if cost effective.
- Improve electricity reliability, quality, and sufficiency by researching and developing a Power Conditioning Unit (PCU) that can:
 - Track the array maximum power point.
 - Invert DC to AC power at no less than 93% efficiency.
 - Operate through a wide range of DC input voltages to enable single-string arrays of various sizes.
 - Incorporate all AC and DC switching and protective devices and designing flexibility, such as array size and battery usage.

Proposed Outcomes:

Research and develop a PV module/laminate product and associated mounting and wiring system that:

- Will be accepted by mainstream consumer markets.
- Reduces or eliminates penetrations of the roofing membrane (flashed "feet") for new construction.
- Functions as part of a weatherproofing system, though not necessarily a "Building Integrated PV" product.
- Presents an appearance that is more consistent with conventional roofing, and minimizes or eliminates the visibility of mounting or wiring hardware from the ground.
- Works with the majority of the roofing products predominant in sloped-roof residential construction in California, including Spanish tile and concrete tile.
- Eliminates the need for inter-module hardwiring and conduit on the roof.

Project Status:

Project is underway. AstroPower has developed a photovoltaic module that works with concrete tile roofing systems found on California homes. Demonstration project and product enhancements are accomplished according to the project goals and objectives.

Project 3.6 Remote Dispatch & PV Irrigation

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 3.6 PV Irrigation.

Project Amount: \$77,000

Match Funding: \$150,000

Contract Project Manager: World Water Corporation, Quentin T. Kelly (609) 818-0700

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe (916) 654-4412

Commission Technical Lead: Joseph McCabe (916) 654-4412

Project Description: Designs for two PV irrigation projects will be completed: one grid-connected and one stand-alone. Both designs will be implemented in demonstration projects. The demonstration projects will be monitored and evaluated. The demonstration projects will be used to test the PV-based spot market for electricity sales. Many agricultural wells in Sacramento County are fairly large, so the PV systems may be large enough produce sufficient electricity, if aggregated, to be of interest as spot-market generators.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by evaluating irrigation requirements with respect to pumping horsepower, monthly hours of operation and preferred time of irrigation; and

- Improving electricity reliability, quality, and sufficiency by developing PV-powered irrigation systems designs and demonstration projects.

Proposed Outcomes:

- Create the basis for a PV agriculture irrigation program in the Sacramento area.
- Test market for remote dispatch of PV systems in agricultural applications.
- Evaluate the need for battery storage for a variety of situations.
- Design systems with optimized PV and battery sizing.
- Implement two demonstration projects – one grid connected and one grid-independent.

Project Status:

The bidding process has identify World Water Corporation as the technical contractor. Project is currently underway.

Project 3.7 PV and Evaporative Cooling

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 3.7 PV Evaporative cooling

Project Amount: \$ 50,000

Match Funding: \$ 30,000

Contract Project Manager: Davis Energy Group, Dick Bourne 530-753-1100

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe 916-654-4412

Commission Technical Lead: Joseph McCabe (916) 654-4412

Project Description: PV will be tested for use with locally manufactured two-stage evaporative cooling units in residential demonstration projects. Two types of demonstration projects will be implemented:

- (1) PV delivering 115VAC power to a home with a two-stage unit, and
- (2) PV delivering 48VDC directly to a unit modified to accept DC power and 115VAC to the home or grid when there is no demand for cooling.

The installations will be monitored and the results presented in a final report.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by laying the groundwork for creating a new market for PV and begin to address air conditioning as a peak-load driver; and
- Providing greater choices for California consumers by

monitoring and evaluating the demonstration projects.
Building a DC-operated indirect/direct evaporative cooling unit.

Proposed Outcomes:

Complete a demonstration project with 115VAC PV and a 115VAC evaporative cooling unit. Complete a demonstration project with 115VAC/48VDC PV and a 48VDC evaporative cooling unit

Project Status:

The bidding process has identified Davis Energy Group as technical contractor. Project is currently underway.

Project 3.8 Solar Dish Concentrating with Stirling Engine

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 3.8 SAIC Solar Dish

Project Amount: \$1,301,000

Match Funding: \$190,000

Contract Project Manager: Rob Taylor, (858) 826-9124

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe (916) 654-4412

Commission Technical Lead: Joseph McCabe (916) 654-4412

Project Description: SAIC is proposing to develop a 20-25 kW solar dish/Stirling system and design a solar dish/photovoltaic system and install a demonstration system of the solar dish/Stirling system in SMUD's service territory. An option to install the solar dish/photovoltaic system may be selected only if very favorable results occur in the development of the SAIC dish/PV program and there are problems with the dish Stirling system. This demonstration will prove the performance and reliability so that MW- scale solar farms can be built in California and exported to the other Southwestern States and internationally.

This Project supports the PIER Program objective of:

- Providing greater choices for California consumers by installing the solar dish/Stirling system as a demonstration in Sacramento; and
- Improving electricity reliability, quality, and sufficiency by fabricating fixed focal length mirror facets for a solar dish/PV system and design the integration of the SAIC solar concentrating dish with a 20 kW PV receiver.

Proposed Outcomes:

Integrate the proven SAIC solar concentrating dish with the 25 kW STM Beta Stirling engine, achieve 22% solar conversion

efficiency with 90% availability. Based upon other SAIC dish/PV programs and the results from this design work, a dish/PV system may be installed in Sacramento if it is agreed that it has substantial economic and reliability advantages over the dish / Stirling system.

Project Status:

Project is currently underway with a critical decision making point in the summer of 2003.

Emphasis Area 4: Developing Renewable Technologies for Tomorrow's Electricity System

Project 4.1 Non-Vacuum Thin-Film CIGS Modules (SMUD/ReGen)

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 4.1 Non Vacuum CIGS

Project Amount: \$470,812

Match Funding: \$496,000

Contract Project Manager: Chris Eberspacher (805) 987-7258

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe (916) 654-4412

Commission Technical Lead: Joseph McCabe (916) 654-4412

Project Description: The purpose of this project is to explore a simple, low-cost alternative based on non-vacuum processes. The PV industry is currently dominated by solar cells fabricated from wafers of high purity silicon. The underlying cost of semiconductor wafers constrains the cost reduction potential of wafer-based PV technologies. One of the most promising strategies for lowering the cost of PV is the use of thin-film technologies in which thin coatings of PV materials are deposited on inexpensive substrates like window glass. However, the vacuum techniques typically used to deposit PV thin films are complex and capital intensive. The basic concept is to prepare fine powders of precursors materials, deposit thin layers of particulate materials using simple non-vacuum techniques, and convert the layers into high-quality PV films by reactive sintering. Reactive sintering techniques facilitate film densification at low temperatures.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by demonstrating that low-cost non-vacuum processing can yield large and efficient PV modules; and
- Improving electricity reliability, quality, and sufficiency by developing the equipment and processing parameters necessary to fabricate multi-cell modules using particles-based non-vacuum processes.

Proposed Outcomes:

Fabricate efficient thin-film PV modules using particles-based non-vacuum processes. Extend innovative new techniques to fabrication of larger-area modules. This project is a longer-term research project, which supports the PIER Program objectives of developing a new generation of low-cost renewable technologies for tomorrow's electricity system. Such cost reductions will significantly accelerate the commercialization of thin-film CIGS PV technology and deliver to California electricity ratepayers the benefits of low-cost, clean energy from renewable solar power.

Project Status:

Small-area modules (1" x 1") were fabricated and tested.

Project 4.2 Maximum Power Point Tracker Inverter Development

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 4.2 SMA Inverter

Project Amount: \$708,900

Match Funding: \$120,000

Contract Project Manager: John Berdner (530)-273-4895

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe (916) 654-4412

Commission Technical Lead: Joseph McCabe (916) 654-4412

Project Description: Develop and field-test a PV inverter incorporating both maximum power point tracking and dispatchable energy storage functions.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by developing low cost grid feeding inverter incorporating both maximum power point tracking functions and backup power capabilities; and
- Providing greater choices for California consumers by developing a remote dispatchability capability for renewable power systems. Demonstrating in field trials to verify the effectiveness of customer sited renewable power systems as an energy management tool.

Proposed Outcomes:

The outcome of the proposed project will be the availability of a low-cost energy conversion unit that maximizes the value of renewable energy systems with energy storage. This product will better meet the needs of the California consumer and thereby accelerate the widespread adoption of renewable energy systems in the State. A secondary outcome will be the demonstration of the economic value of dispatchable energy storage functions in renewable energy systems.

Project Status:

Project is currently underway.

Project 4.3: Hybrid PV/Lighting System (SMUD / ReGen)

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 4.3 ORNL Hybrid Lighting

Project Amount: \$100,000

Match Funding: \$230,000

Contract Project Manager: Jeff D. Muhs, (865)946-1281

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe 916-654-4412

Commission Technical Lead: Hassan Mohammed (916) 651-9855

Project Description: The purpose of the project is to demonstrate for the first time (in a commercial building setting) the technical feasibility of hybrid lighting systems.

Hybrid lighting is a revolutionary approach to lighting that integrates light from natural and electric sources. Hybrid lighting systems collect and distribute the visible portion of sunlight using large-core optical fibers and combine it with electrically generated light in existing light fixtures. The natural and electric light sources work in unison to light commercial buildings where lighting represents the single largest consumer of electricity. The remaining "invisible" energy in the sunlight, mostly infrared radiation, is directed to a concentrating thermophotovoltaic cell that very efficiently converts infrared radiation into electricity. The resulting electric power can be directed to other uses in the building.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by demonstrating the technical feasibility of a novel solar concentrator that splits the solar spectrum, illuminating building interiors using the visible portion and generating electricity from the infrared portion via low-cost concentrating thermophotovoltaic solar cells; and
- Improving the environment, public health and safety by addressing building code and permitting issues in a commercial setting and developing a system-level building integration strategy.

Proposed Outcomes:

This project supports the PIER Program objectives of developing systems for tomorrow's energy needs that are highly responsive to commercial demand, supply quality-of-life health/productivity benefits, are fully-integrated with customer

appliances (electric lighting) and offset peak demand. The demonstration promises to more than double the overall efficiency, affordability and market penetration of solar energy leading to smart, super-efficient, super-clean renewables having combined generation and displacement efficiencies greater than 70 percent.

Project Status:

This project is not expected to be under contract until 2003. This is a demonstration project, scheduled for installation in 2004.

Project 4.4 Slat-Array Concentrator Development (SMUD/ReGen)

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 4.4 SSV Slat Array Solar

Project Amount: \$347,270

Contract Project Manager: Dr. Sergy Vasylyev (916) 381-1665

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe (916) 654-4412

Commission Technical Lead: Joseph McCabe (916) 654-4412

Project Description: The purpose of this project is to develop and test a slat-array concentrating photovoltaic (CPV) prototype module with increased efficiency and reduced cost and operation. The concentrating photovoltaic (CPV) is an emerging technology which appears to be the least expensive and most efficient of all photovoltaic technologies due to substituting a large fraction of expensive flat-plate PV panels with less expensive concentrators supplied by tracking systems. To fully exploit the advantages of CPV's and achieve relatively high concentration ratios, a number of approaches based on Fresnel lenses and parabolic mirrors have been devised. However, none of the existing solar concentrators provides desired operation at a reasonable cost, thus limiting the acceptance of CPV technology.

This project promises a unique opportunity to naturally combine the robustness and high efficiency of the reflective optics and design conveniences of the Fresnel lens technology in a single and in expensive CPV device based on a novel slat-type concentrator concept. The slat-array module developed in this project will consist of specially designed asymmetric linear concentrator and an array of concentrator silicon solar cells electrically interconnected and mounted on a single wafer. The concentrator will consist of a set of narrow reflective slats reflecting the solar energy to the line-arranged cells. Each reflective slat will have a specific concave profile in the cross section to provide light focusing capability.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by developing and test a slat-array concentrating photovoltaic (CPV) prototype module with increased efficiency and reduced cost and operation; and
- Improving electricity reliability, quality, and sufficiency by significantly improving the practicability of reflective optics by introducing the lens-like slat-array concentrator concept and developing it for uniform illumination of photovoltaic cells at moderate sunlight concentration.

Proposed Outcomes:

This project is a longer-term research project that supports the PIER Program objectives of developing a new generation of low-cost renewable technologies for tomorrow's electricity system.

Project Status:

On-going. Contract began April, 2002.

Project 4.5: Distributed Generation Drivetrain for MW Turbines

Contract #: 500-00-034

Contractor: SMUD Programmatic- Project # 4.5 Dehlsen Geartrain

Project Amount: \$1,299,000

Match Funding: \$836,000

Contract Project Manager: Dr. Amir Mikhail (805) 690-3275

Commission Project Manager: Elaine Sison-Lebrilla, P.E / Joseph McCabe (916) 654-4412

Commission Technical Lead: Dora Yen (916) 653-4128

Project Description: As wind turbines continue to increase in capacity and rotor diameter, gearbox torque loads and component costs increase accordingly. New designs are needed for reducing the cost and increasing the reliability of these the large systems. The Distributed Generation Drivetrain (DGD) technology proposes patent-pending solutions to address the exponentially increasing torque loads on large utility-scale turbine drive trains and at the same time include improvements that decrease system weight and costs. The tremendous load reductions are obtained by splitting the torque along multiple paths at the low speed end of the gearbox between small, parallel gearboxes and multiple off the shelf generators. Extreme loads on individual gear tooth are thereby reduced. These improvements reduce gear teeth wear, gearbox cost and weight, installation requirements, and warranty risks. The focus of the project is to design, construct and test a commercial-scale (1.5MW) DGD along with an integrated controller. The weight savings and torque reduction achieved over current monolithic generator systems will measure project successes.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by engineering a commercially-viable gearbox to either enable cost saving retrofits of existing turbines or provide the drive train for a new lighter weight, low cost turbine design. Providing full cost-scaling and design tradeoff data for a compact multi-generator gearbox design, providing data to determine the optimal number of generators to use for each turbine;
- Improving electricity reliability, quality, and sufficiency by constructing the DGD system, integrating the DGD controller with a new non-patent infringing variable speed capability. In addition, the project performs load testing of the DGD system on the NREL dynamometer test stand; and
- This project reduces gearbox failure by decreasing gear tooth stress, and allows turbine to operate even if one or more generators fails, thus addressing the PIER goals of increased reliability.

Proposed Outcomes:

The 1.5MW single stage DGD is projected to cost under \$100,000 compared to \$170,000 for present turbine gearboxes. The innovative gearbox design allows for either a retrofit of existing turbines or provides the drivetrain for a new low-cost turbine design. Through gearing and multiple path load division, the highest gear tooth stresses (found in the first gearbox stage) are substantially reduced resulting in an overall gearbox drivetrain weight and volume reductions. The significant size and weight savings and use of conventional generators provide as much as 0.4¢/kWh cost of energy reductions for wind turbine generators or 10% COE reductions. Benefits to California include a cost-competitive and reliable turbine fleet, lower COE and environmental and economic benefits of using diversified renewable generation technologies.

Project Status:

Project is currently on track. Preliminary load analysis and design tradeoffs have lead to a optimal gearbox layout and 8 generator configuration. The preliminary DGD design has been finalized and a bill of materials has been sent to gear and gearbox manufacturers, machine shops and foundries. Preparations are being made for assembly and testing at NREL planned for early 2003.

Biogas/PV Micro-Grid Renewable Resource Program

Contract #: 500-00-036

Contractor: Commonwealth Energy Corporation

Subcontractors: Regional Economics Engineering, Inc, Endecon Engineering, Renewable Energy Development Institute, Zaininger Engineering Company, SDV/ACCI, CH2M Hill

Contract amount: \$11,668,572

Match amount: \$11,919,500

Contractor Project Manager: Patrick Lilly (360) 906-0616

Commission Contract Manager: Zhiqin Zhang
(916) 654-4063

Program description: The Commonwealth program consists of one administrative project and six linked renewable energy projects that act in a coordinated fashion to make electricity more affordable. The Commonwealth program will:

- Develop and implement an approach for tailoring resource development to the specific needs and resources of local areas, or mini-grids;
- Develop means of increasing landfill gas production, accelerating biodegradation and decreasing landfill generation lifecycle costs;
- Improve the affordability of renewable energy produced from digester gas at sewage treatment plants
- Improve the economics of producing energy from animal waste;
- Demonstrate the use of proper systems integration to enhance the performance of photovoltaic systems;
- Demonstrate the use of a basic rating system to improve the flow of information on photovoltaic system performance; and
- Demonstrate the potential for taking advantage of cost economies by installing relatively large PV systems under common ownership arrangements

The Commonwealth program supports PIER renewables emphasis areas of:

- 1) Assessing and Targeting Renewable Electricity Development,
- 2) Increasing Affordability by Improving Existing Renewables Investments, and
- 3) Expanding Affordability and Diversity Using Renewable Distributed Generation.

The Commonwealth Program supports the PIER Program objective(s) of:*Emphasis 1: Assessing and Targeting Renewable Electricity Development*

- Conducting power flow modeling that identifies existing or anticipated problems with the electricity systems in the targeted region over the next five, ten and fifteen years;
- Compiling information on the availability of renewable and fossil resources in the target region and information on critical constraints or issues in the region;
- Matching electricity needs and desired affordability goals with desired renewable electricity generation performance and cost characteristics; and
- Developing a plan of coordinated research and development

efforts that will enable the desired electricity generation performance characteristics and cost targets to be achieved in the target region.

Emphasis Area 2: Increasing Affordability by Improving Existing Renewable Investments

- Improving efficiencies and lowering O&M;
- Establishing new and diversified revenue streams that help with capital cost recovery and therefore help lower electricity generating costs; and
- Developing the ability to provide ancillary services or peak generating capabilities.

Emphasis Area 3: Expanding Affordability and Diversity Using Renewable Distributed Generation

- Developing renewable distributed generation technologies that can match the demand profiles of the appropriate demand centers, help defer transmission and distribution expansions or upgrades, provide power quality benefits to the customer or the electricity system, help provide volt-ampere reactive (VAR) support and have very low emissions or other environmental impacts; and
- Integrating renewable electricity generation technologies and other technologies using dynamic control systems in a manner to produce high performance "mini-grids" capable of providing lower cost power with high availability, reliability, power quality and environmental cleanliness. Note that integration is not limited to renewable energy technologies. Hybrid combinations of renewable and fossil technologies can be used, as well as combinations of building technologies and renewables.

Proposed outcomes:

Proposed Outcomes for project 1.1:

- Develop analytical tool to match renewables mixes to the forecasted pattern of local area demand.
- Demonstrate how generation facilities can be made more cost effective and the energy they produce more affordable.
- Develop measurement and evaluation plans under this project should allow other projects to be designed in ways that maximize their usefulness in achieving overall program objectives.

Proposed Outcomes for project 2.1:

- Develop a conceptual design for two types of landfill bioreactors.
- Develop two types of landfill bioreactors.
- Develop environmental documentation to satisfy regulators.
- Incremental gas production from both of these pilot reactors will be in the range of 1 to 5 MW.

Proposed Outcomes for project 2.2:

- Employ technologies to improve gas production and energy generation and the overall efficiency of their facility.
- Increase and optimize digester gas production through thermal hydrolysis and ultrasound processes.
- Develop and optimize cost-effective gas cleanup systems.
- Evaluate and quantify environmental benefits that result from using micro-turbines at sewage treatment plants.
- Evaluate performance and cost during operation so sewage treatment plants have greater certainty on cost and reliability of using micro-turbines.

Proposed Outcomes for project 3.1:

- Demonstrate key technical component to allow such projects to be economic is the development of an integrated waste management/energy recovery system.
- Develop technologies that can be used to maximize the energy recovery from animal waste.
- Develop and evaluate different pilot projects that will include facilities at existing treatment plants and at individual and clusters of dairies.
- Evaluate and test the effectiveness of low and high technologies developed in North America and Europe for the collection processing and energy recovery of animal waste.

Proposed Outcomes for project 3.2:

- Address the gap between future third-party certified PV component and system performance results and currently available information from manufacturers
- Provide an independent comparative evaluation of PV systems critical to Project 3.3 and to the Commission Buydown Program
- Provide decision-making information on those PV systems.

Proposed Outcomes for project 3.3:

- Establish credibility of the implementation model.
- Improve consumer affordability to higher cost systems.
- Reduce installed PV costs per peak watt and per life cycle kWh.
- Find ways to add outside inherent value to the PV system installation over its life.

Program Status:

The program is scheduled from 5/28/2002 to 2/24/2006. The Commonwealth program kick off meeting was held on May 29, 2002 at the California Energy Commission. The program is currently on schedule and within the budget.

Commonwealth Project 1.1 – Program Planning and Analysis

Contract Project Amount: \$1,336,613

Match Funding: \$20,000

Contract Project Manager: David Hanna (858) 481-0081

Commission Project Manager: Zhiqin Zhang (916) 654-4063

Project Description: The purpose of this project is to develop formal means of assessing the potential for meeting sub regional needs with local renewable resources for one or two areas within California, and to apply this approach to the development of biogas and solar photovoltaic generation facilities for at least one of these areas. The project will cover:

- assessments of regional energy needs,
- assessments of biogas and solar resources, and
- evaluation of regional grid conditions through power flow modeling.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by determining the most appropriate renewable resources in the region of interest to fully serve the electric distribution grid.

Proposed Outcomes:

- Develop analytical tool to match renewables mixes to the forecasted pattern of local area demand.
- Demonstrate how generation facilities can be made more cost effective and the energy they produce more affordable.
- Development of measurement and evaluation plans under this project should allow other projects to be designed in ways that maximize their usefulness in achieving overall program objectives.

Project Status:

The project is scheduled from 6/5/2002 to 6/7/2003. The Commonwealth program kick off meeting was held on May 29, 2002 at the California Energy Commission. The project is currently on schedule and within the budget.

Commonwealth Project 2.1 - Enhanced Landfill Gas Using Bioreactors

Contract Project Amount: \$2,315,999

Match Funding: \$800,000

Contract Project Manager: Bill Kitto (503) 235-5022-4427, Patrick Lilly (360) 906-0616

Commission Project Manager: Zhiqin Zhang (916) 654-4063

Project Description: The purpose of this project is to design, develop, and demonstrate two types of bioreactors capable of:

- increasing landfill gas production,

- accelerating the biodegradation process, and
- decreasing landfill generation lifecycle costs.

One bioreactor will be designed to use municipal solid waste (MSW) or source-separated organic waste materials, and the other will be designed to use MSW or source-separated organic waste materials along with animal waste. Performance metrics will include measurement of changes in methane production estimation of direct reductions in CH₄ emissions and indirect reductions in other criteria air emissions associated with displaced conventional generation and assessment of changes in lifecycle costs of generation from landfill gas.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California electricity by designing, developing and demonstrating two types of bioreactors capable of increasing landfill gas production, accelerating the biodegradation process and decreasing landfill generation lifecycle costs; and
- Improving the environment, public health, and safety by quantifying greenhouse gas and pollution reduction benefits.

Proposed Outcomes:

- Develop a conceptual design for two types of landfill bioreactors.
- Develop two types of landfill bioreactors.
- Develop environmental documentation to satisfy regulators.
- Incremental gas production from both of these pilot reactors will be in the range of 1 to 5 MW.

Project Status:

The project is scheduled from 11/4/2002 to 2/25/2006. The Commonwealth program kick off meeting was held on May 29, 2002 at the California Energy Commission. The project is currently on schedule and within the budget.

Commonwealth Project 2.2 - Enhanced Energy Recovery through the Use of Microturbines and Optimization of Anaerobic Digestion

Contract Project Amount: \$2,153,740

Match Funding: \$482,000

Contract Project Manager: Bill Kitto (503) 235-5022-4427, Patrick Lilly (360) 906-0616

Commission Project Manager: Zhiqin Zhang (916) 654-4063

Project Description: The purpose of this project is to develop and optimize biogas cleanup systems and study the digester performance improvement through thermal hydrolysis and ultrasound pretreatment. At least three gas cleaning systems will be defined and optimized. It is anticipated that one of these

systems will involve hydrogen sulfide removal, gas drying, and siloxane removal. A second system will likely involve gas drying and siloxane removal. A third system, with parameters not yet defined, will also be formulated. For the digester gas production improvement processes (thermal hydrolysis and ultrasound), the focus will be on evaluation of the systems, their impact on gas production, and their cost effectiveness.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California electricity by the development of piloting of thermal hydrolysis and ultrasound treatment systems to increase biogas production; and
- Improving the environment, public health, and safety by developing and testing gas cleaning system well suited for microturbines, it will be possible to reduce installation, operation, and maintenance costs and achieve emissions reductions.

Proposed Outcomes:

- Employ technologies to improve gas production and energy generation and the overall efficiency of their facility.
- Increase and optimize digester gas production through thermal hydrolysis and ultrasound processes.
- Develop and optimize cost effective gas cleanup systems.
- Evaluate and quantify environmental benefits that result from using micro-turbines at sewage treatment plants.
- Evaluate performance and cost during operation so sewage treatment plants have greater certainty on cost and reliability of using micro-turbines.

Project Status:

The project is scheduled from 6/19/2002 to 3/19/2005. The Commonwealth program kick off meeting was held on May 29, 2002 at the California Energy Commission. The project is currently on schedule and within the budget.

Commonwealth Project 3.1 - Dairy Waste to Energy

Contract Project Amount: \$3,274,664

Match Funding: \$4,855,000

Contract Project Manager: Bill Kitto (503) 235-5022-4427, Patrick Lilly, (360) 906-0616

Commission Project Manager: Zhiqin Zhang (916) 654-4063

Project Description: The purpose of this project is to test and demonstrate the use of several advanced technologies to enhance the process of generating energy from animal waste. Means of improving the digesting process include options such as high-rate, phased digestion, pre-hydrolysis processes (thermal hydrolysis), and co-digestion with wastewater sludge

can improve economics of anaerobic digestion. Technologies that will be applied to improve economics of handling these streams include membranes separation processes, gasification or heat drying, and belt press and centrifuge dewatering equipment. Screening and grinding equipment will be pilot tested to develop and optimize equipment for these applications.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by focusing on the combined system's comprehensive results including captured environmental benefits, transmission/distribution savings, and individual technology elements associated with waste treatment.

Proposed Outcomes:

- Demonstrate key technical component to allow such projects to be economic is the development of an integrated waste management/energy recovery system.
- Develop technologies that can be used to maximize the energy recovery from animal waste.
- Develop and evaluate different pilot projects that will include facilities at existing treatment plants and at individual and clusters of dairies.
- Evaluate and test the effectiveness of low and high technologies developed in North America and Europe for the collection processing and energy recovery of animal waste.

Project Status:

The project is scheduled from 9/13/2002 to 12/31/2004. The Commonwealth program kick off meeting was held on May 29, 2002 at the California Energy Commission. The project is currently on schedule and within the budget.

Commonwealth Project 3.2 - Building Integrated PV Evaluation

Contract Project Amount: \$870,099

Match Funding: \$602,500

Contract Project Manager: Bill Brooks (707) 332-0761, Chuck Whitaker, (925) 552-1330, Patrick Lilly (360) 906-0616

Commission Project Manager: Zhiqin Zhang (916) 654-4063, Joseph McCabe (916) 654-4412

Project Description: The purpose of this project is to develop two information-related services: creation of objective, third-party module and complete system performance assessments, and dissemination of significant findings to supply- and demand-side stakeholders. Performance assessments will be based on analysis of data collected during 12 months of outdoor operation. Hardware will be purchased randomly to

minimize the potential for hardware selection bias. Selection criteria for modules will be specified in a manner that will maximize the contribution of results to improving other areas of the program. Significant findings will be disseminated on a web site, in periodic and topical reports and papers, and at conferences, meetings, and workshops.

This Project supports the PIER Program objective of:

- Improving electricity reliability, quality, and sufficiency improving the quality of systems installed through directed training.

Proposed Outcomes:

- Address the gap between future third-party certified PV component and system performance results and currently available information from manufacturers
- Provide an independent comparative evaluation of PV systems critical to Project 3.3 and to the Commission Buydown Program
- Provide decision-making information on those PV systems.

Project Status:

The project is scheduled from 6/20/2002 to 9/23/2004. The Commonwealth program kick off meeting was held on May 29, 2002 at the California Energy Commission. The project is currently on schedule and within the budget. Multiple conference calls have been held with industry experts from across the nation. A PV System Evaluation Plan was developed and criteria for choosing small and large-scale systems were determined.

Commonwealth Project 3.3 - Building Integrated PV (BIPV) Generation

Contract Project Amount: \$827,686

Match Funding: \$2,350,000

Contract Project Manager: Keith Rutledge (858) 481-0081, Patrick Lilly (360) 906-0616

Commission Project Manager: Zhiqin Zhang (916) 654-4063, Joseph McCabe (916) 654-4412

Project Description: The purpose of this project is to develop several important services. The services, which are in three distinct but related areas, include:

- demonstrating BIPV systems and innovative project development models,
- facilitating relationships between supply- and demand-side stakeholders, and
- initiating contact with stakeholders.

Four photovoltaic systems will be developed to demonstrate

creative implementation models for building-integrated photovoltaics in public sector facilities. Several services aimed at facilitating project development will be developed in parallel with the demonstration projects. Services that will facilitate others' implementation of BIPV projects include development and demonstration of alternative ownership models, providing access to financing and bulk-purchase equipment pricing, and developing and sharing analytic tools necessary to evaluate the economics of potential projects. Lastly, the project will involve direct contact with large numbers of supply- and demand-side stakeholders, thereby initiating projects in situations where opportunities exist but the elements necessary for successful project development would not otherwise have been brought together.

This Project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by increasing the diversity of electricity supply and the affordability of renewables.

Proposed Outcomes:

- Establish credibility of the implementation model.
- Improve consumer affordability to higher cost systems.
- Reduce installed PV costs per peak watt and per life cycle kWh.
- Find ways to add outside inherent value to the PV system installation over its life.

Project Status:

The project is scheduled from 6/20/2002 to 3/1/2005. The Commonwealth program kick off meeting was held on May 29, 2002 at the California Energy Commission. The project is currently on schedule and within the budget. A conference call was held to review the REDI Basic Energy Audit Form and the approach of the project.

Powerwheel Demonstration

Contract #: 500-97-037

Contractor: Powerwheel Associates

Subcontractors: Ideal Electric Co., Electrical Maintenance Consultants, Granger Engineering Services, N. J. Mccutchen, Inc., ERC, Inc., California State University, California Polytechnic Institute, San Luis Obispo, Johnson's Building Inspection Service

Contract amount: \$394,156

Match amount: \$394,000

Contractor Project Manager: Kenneth Broome (650) 529-1810

Commission Contract Manager: Michael Kane (916) 654-7119

Project Description: The purpose of this project is to prove the technical, economic, and environmental suitability of the PowerWheel technology for converting energy from low-head waterfalls into cost-competitive electricity. A 75 kW PowerWheel will be demonstrated in an irrigation canal and the electricity generated by it will be distributed to nearby agricultural, industrial, commercial, and residential customers through an interconnection with the electricity grid.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity as it is expected that electricity from this source will be more reliable than wind and solar energy;
- Improving the energy cost/value of California's electricity by providing electricity at a lower cost than conventional hydroelectricity costs; and
- Improving the environmental and public health costs/risks of California's electricity by displacement of electricity generated by combustion processes resulting in the reduction of exhaust gases of about 250 tons/kW/year of PowerWheel installations. In addition, PowerWheel installations will have no adverse impacts on water quality and may enhance the dissolved oxygen content of the water.

Proposed Outcome:

- Prove the full-scale technical, economic, and environmental suitability of PowerWheel technology for conversion of the presently wasted renewable energy available in very low-head waterfalls into electricity.

Project Status:

The Contractor lost the original host site for the PowerWheel demonstration. They were able to locate and secure another site but in doing so fell behind schedule. Additional cost was incurred because the PowerWheel unit had to be modified for the new site, leading to the contract being augmented \$194,156 in April 2002. The PowerWheel was modified and installed in an irrigation canal in Kern county for testing, but soon experienced mechanical difficulties. The contractor made repairs and is currently waiting for water deliveries to the canal to be resumed in March 2003. As a result, the project remains behind schedule and short of funds.

Utilization of Waste Renewable Fuels in Boiler with Minimization of Pollutant Emissions

Contract #: 500-98-037

Contractor: Energy and Environmental Research Corporation
Subcontractors: Environmental Research Corporation, University of California, Davis, T.R. Miles Consultants, Stanford University

Contract amount: \$981,952

Match amount: \$610,238

Contractor Project Manager: Vladimir Zamansky
(949) 859-8851

Commission Contract Manager: Rajesh Kapoor (916) 654-4611

Project Description: The purpose of this project is to develop an innovative technology, Close-Coupled Gasification (CCG), which is a synergistic combination of the direct combustion, biomass/waste gasification, and GE-EER's emission control approaches to be applied in the existing California biomass boilers. The CCG technology focuses on bringing the renewable energy, energy supply reliability, energy price stability, and protection of the environment to the California marketplace. The CCG technology will also help to solve the existing problems of the biomass power industry in California. The continued survival of the biomass power industry greatly depends on the expansion of availability of diverse, low-cost fuel sources, and this project develops specific feedstocks to be used in the combined combustion/gasification mode.

The goal of this project is to develop a preliminary conceptual design for a full-scale demonstration facility of CCG technology. The design would retrofit (couple) CCG technology in a California biomass power plant to reduce the NO_x emissions by using the gasified, low-grade biomass/waste fuel. This project is Phase I of a four-phase CCG technology commercialization plan. If analyses prove that the project would be technically and economically feasible, the project developers may decide to design, retrofit and operate the demonstration facility (Phases II and III) and to commercialize the technology throughout California and elsewhere (Phase IV).

This project supports the PIER Program objectives of:

- Improving environmental and public health risks/costs of California's electricity by developing a lower-cost method for existing biomass power plants to control NO_x and other pollutant emissions; and
- Maximizing the market connection for the project's research results. Specifically, three California biomass power plants, which are potential partners in the full-scale CCG technology demonstration, will participate in this project's design and economic studies to determine if the technology will provide economic and operational benefits to their units.

Proposed Outcomes:

Specific technical outcomes:

- Design and development of an economic process (demonstration facility), which is capable of converting biomass/waste into gaseous fuel to be used as supplementary

cofiring/reburning fuel and NO_x control in California biomass boilers.

- Produce 10-30 percent of gaseous fuel (by heat input) for a 25 MW biomass boiler
- Reduce NO_x emissions up to 65 percent in basic reburning and 90 percent in advanced reburning and complying with all other California emissions standards.

Specific economic outcome:

- Reduce NO_x control costs by at least 20 percent, compared to the costs of existing NO_x control methods used by biomass boilers owned by Wheelabrator Shasta/Hudson Energy Company, Woodland Biomass, and Wadham Energy.

Project Status:

- The first project review meeting for phase I of the program was held in the GE-EER office on August 2, 2001. The second critical project review meeting was held at UC, Davis on 18th April, 2002. Rajesh Kapoor, Val Tiangco, George Simons, Elaine-Sison Lebrilla and Prab Sethi from CEC attended the review meeting at UC, Davis.
- UC, Davis submitted the draft report for the Laboratory Scale Gasification Screening Experiments.
- Stanford University group performed the laminar flow reactor (LFR) tests on the biomass fuels (rice straw, waste paper, almond shells, wood P, wood W) with different sizes and measured the mass loss for these particles.
- GE-EER conducted the cofiring and reburning tests with the palletized biomass fuels.
- GE-EER conducted the process/kinetic modeling to predict the reburning performance of gasified biomass products. This modeling explains the behavior of the data, and suggest the methods to optimize the reburning performance by conducting the parametric evaluations.
- GE-EER conducted the economic and market analysis to determine the potential applications for CCG technology after a full scale demonstration.
- GE-EER prepared the production readiness plan to identify the hazardous or non-recyclable materials, critical production processes, equipment, facilities, manpower, and support systems that will be needed to produce a commercially viable product.
- The contractor submitted the draft reports for all the tasks. The final report is due next month.
- For the technology transfer, a paper entitled *Integration of Direct Combustion with Gasification for Reduction of NO_x Emissions* was presented and published in the proceedings of the 29th International Symposium on Combustion held in Sapporo, Japan from July 21-26, 2002. A paper entitled "Gasification Combustion Technology for Utilization of Waste Renewable fuels" related to this project was also presented

and published in the proceedings of the Bioenergy 2002 Conference held in Boise, Idaho on September 22-26, 2002. Valentino Tiangco from CEC attended this conference.

The project is within the budget and is expected to achieve the goals.

Collins Pine Co. BCI Cogeneration Project

Contract #: 500-98-043

Contractor: Collins Pine Company

Subcontractors: BC International (BCI), National Renewable Energy Laboratory (NREL), Plumas Corporation, Kemestrie, TSS Consultants, ProForma Systems, Inc., Tembec Inc., Raphael Katzen Associates International Inc., CIFAR

Contract amount: \$1,148,961

Match amount: \$382,274

Contractor Project Manager: Wade Mosby (503) 417-7755

Commission Contract Manager: Zhiqin Zhang (916) 654-4063

Project Description: The purpose of this project is to determine the technical and economic feasibility of integrating a new biomass-to-ethanol facility with an existing biomass power plant, located in Chester, California. If feasible, these two facilities would be operated together and become customers for each other's products. The ethanol facility would produce lignin for sale to the biomass boiler, which it would use to generate electricity and steam. In addition, the biomass power plant would generate electricity and steam for sale to the ethanol facility.

This project seeks to lower the biomass power plant's electricity-generating costs so that it can become more cost-competitive after subsidies for renewable energy power plants expire in 2004. The lignin fuel supply from the ethanol facility may help to lower the biomass power plant's costs of generating electricity. The ethanol facility would also generate income by producing and selling ethanol and other value added co-products to customers outside of Chester, CA. The project is Phase I of a four-phase effort. If the results of Phase 1 are technically and economically positive, then facility developers may proceed with subsequent phases to design, permit, finance, construct and operate the ethanol facility.

This project supports the PIER Program objective of:

- Improving system reliability and power quality of California's electricity by seeking a cost-effective way to operate a distributed generation power plant in a rural area, which is prone to electricity supply disruptions; and
- Maximizing market/economy connection by providing

positive impacts to a California local economies by the creation of new jobs and new tax revenues in a rural area;

Specific Technical Outcomes:

- Determine whether the ethanol facility can produce up to 20 million gallons per year of ethanol from softwood feedstock using BCI technologies;
- Determine whether lignin from the ethanol facility can partially displace the existing fuel of Collins Pine biomass power plant by 30 percent to 60 percent; and
- Identify at least one co-product, other than lignin or ethanol, which can be produced by the ethanol facility.

Specific Economic Outcomes:

- Reduce the cost of electricity production at the Collins Pine biomass power plant by at least 1.5 cents/kWh.
- Identify at least one co-product, other than lignin or ethanol, which can be produced by the ethanol facility and has a value of at least \$2/pound

Project Status:

- The Commission issued a stop work order to the Collins Pine Contract on September 19, 2001 due to problems with Collins Pine's subcontractor, BCI, for unsatisfactory performance, and lacking of capabilities to meet the work schedules and provide deliverables on time
- Based on a review of the documentation sent by BCI, we believe that BCI has still not adequately responded to the concerns.
- The Contract manager has met with the PIER renewable team leads and decided to terminate the Collins pine contract. This determination will be brought to the policy committee for concurrence and then to the full commission for official approval at a scheduled business meeting.

The Flex-Microturbine Uniquely Adapted to Low Pressure Biomass Gas

Contract #: 500-99-030

Contractor: FlexEnergy, Inc.

Subcontractors: Capstone Turbine Corporation, National Renewable Energy Laboratory, University of California- Davis, Capstone Turbine Corporation, National Renewable Energy Laboratory

Contract amount: \$983,653

Match amount: \$3,997,506

Contractor Project Manager: Edan Prabhu (949) 380-4899

Commission Contract Manager: Prab Sethi (916) 654-4509

Project Description: The purpose of this project is to design, develop and demonstrate a Flex-Microturbine™ that will run on

different biomass fuels, namely:

- Biogas generated from anaerobic digestion of livestock manure;
- Producer gas generated from thermal gasification of orchard and forest residues; and
- Biogas from landfill gas recovery system.

This new Flex-Microturbine™ is intended to act as safe, reliable, clean, cost-competitive provider of renewable energy with particular value to California's deregulated electricity marketplace.

This project is Phase II of small modular biomass (SMB) initiative co-funded by the National Renewable Energy Laboratory (NREL)/US Department of Energy (US DOE). In this Phase II, the Contractor will design, develop and demonstrate a proof of concept (POC) and three prototypes of Flex-Microturbine™. Prototype 1 will be fueled from biogas generated from anaerobic digestion of livestock manure. Prototype 2 will be fueled from producer gas generated from thermal gasification of orchard and forest residues. Prototype 3 will be fueled from landfill gas. Prototypes 1 and 2 are funded by PIER and co-funded by NREL/US DOE. Prototype 3 is funded by NREL/US DOE only and not part of the PIER project. Phases I and IA of the SMB initiative are feasibility and preliminary design stages, respectively. Phases 1 and IA are completed and funded through NREL/US DOE.

This project supports the PIER Program objectives of:

- Improving cost competitiveness of the biomass energy conversion technologies, and reducing costs of California's electricity;
- Improving environmental and public health costs/risk of California's electricity by mitigating air quality impacts and reducing environmental risks; and
- Improving the reliability/quality of California's electricity by developing a new distributed generation technology.

Proposed Technical Outcomes:

The technical objective of this project is to design, develop and demonstrate a Flex-Microturbine™. The turbine will have the ability to run on low pressure and low Btu gases from biogas generated from the anaerobic digestion of livestock manure, from producer gas generated by thermal gasification of orchard and forest residues, and biogas from landfill gas recovery systems.

Specific technical performance objectives of this project are:

- Proof-of-Concept (POC): The following activities will demonstrate that a fuel and air mixture of 100 Btu/scf to 800 Btu/scf can be successfully and safely mixed and used to

achieve combustion in a microturbine, using natural gas as the fuel. These activities will address three applications:

1. Attain successful combustion for 4 hours for the specified mixtures
2. Measure emissions, including NO_x and hydrocarbons
3. Measure temperatures, pressures, output and other pertinent performance parameters

For Prototype 1 (Digester Gas and Demonstration Unit)

- Conduct shop tests as in POC
- Demonstrate safe startup and shutdown
- Demonstrate ability to accept fuel gas at less than 0.25 psig
- Operate for 7 days on digester gas
- Ammonia-free NO_x emissions below 9 PPM (15 %O₂)
- Attain at least 25% gas-to-electricity efficiency (13,684 Btu/kWh, LHV)
- Ability to load follow (operate at different loads, 20% to 80% capacity)
- Ability to handle wide variation in fuel Btu content (200 to 800 Btu/scf)

For Prototype 2 (Wood Gasifier Prototype and Demonstration Unit)

- Demonstrate capability to operate for at least 8 hours at a time for 5 days in a row
- Demonstrate ability to accept gas at below 0.25 psig
- Demonstrate safe startup and shutdown
- Demonstrate capability to run on gas with normal rated gasifier output (112 Btu/scf, 5 PPM tar, 5 PPM particulates)
- Attain at least 25% gas-to-electricity efficiency (13,684 Btu/kWh, LHV)
- Ability to handle gas Btu variations (with a minimum of 100 Btu/scf)
- Ability to run on below normal gas quality (100 Btu/scf gas) for 8 hours
- Test ability to run three Flex-Microturbines running on one gasifier
- NO_x emissions below 9 PPM (@15 % O₂)
- Particulate emissions below 0.02 lb./MWH

For Prototype 3 (Landfill Gas Prototype and Demonstration Unit)

- Demonstrate safe startup and shutdown
- Attain at least 25% gas-to-electricity efficiency (13,684Btu/kWh, LHV)
- Demonstrate ability to accept gas at below 0.25 psig
- Operate continuously for 30 days
- NO_x emissions below 9 PPM (@15 % O₂)
- PM10 Particulate emissions below 0.02 lb./MWH
- Demonstrate ability to run on gases as low as than 100

Btu/scf for 24 hours

Proposed Economic Outcomes:

The economic objective of this project is to develop the Flex-Microturbine™ to provide cost competitive renewable energy in a deregulated electricity marketplace.

The specific economic objectives of this project in mature commercial volumes are:

- The Flex-Microturbine™ will be available for about \$400 a kW. This price assumes the global sales of microturbines over 10,000 a year.
- In landfill gas applications, where the gas is already available in most landfills in the state, power will be produced for less than \$0.03 a kWh with a capacity factor of 90%.
- The entire power plant, including a manure digester, will cost about \$800 a kW when about one hundred digesters are installed. Power will be produced from digester gas at about \$0.03 a kWh with a capacity factor of 90% without considering the benefit of energy and environmental credits
- The portable wood gas power plant, including the gasifier, will be available for \$1000/kWh, in volumes of over one hundred a year. Power will be produced for less than \$0.05 a kWh.

Project Status:

The project kick-off meeting was held at the Capstone offices in Chatsworth, California on July 26, 2000. The following is a list of project activities:

- The contractor has completed design of the POC assembly including catalytic combustor and electrical heater.
- Convection heaters and new catalyst have been installed and tested.
- A Project Advisory Board Meeting and a test demonstration was held on October 23, 2001 at the Capstone facilities in Van Nuys, CA to review the test results of the Proof-of-Concept (POC) Flex-Microturbine. This meeting was attended by more than 15 project sponsors, end-users, research and academia and utility, including US Department of Energy, LADWP, and University of California, Davis. Prab Sethi, Project Manager, and Valentino Tiangco, Biomass Manager, represented the Energy Commission.
- Following the presentation, the following demonstration was presented to the Advisory Board members:
 - Startup, operation and shutdown of a POC Flex-Microturbine running on a mixture of hydrogen and carbon monoxide. The system ran up to about 15 kW, roughly steady state under manual control.
 - Startup, operation and shutdown of a POC Flex-Microturbine running on natural gas diluted with air down to 1.5- percent methane. The system was run at 25 kW.

The Flex-Microturbine speed was then raised to 96,000 rpm and the fuel concentration increased to 1.75- percent methane. Power output peaked at 35 kW.

- A Critical Project Review meeting was held after receipt of the POC test report. After satisfactory review, this project was permitted to proceed with the design and demonstration of Prototype 1.
- Work for the design and testing of the Prototype 1 and 2 is in progress.

Evaporative Cooling of Geothermal Power Plants with Recycled Water

Contract #: PIR-00J-002

Contractor: Mammoth Pacific Limited Partnership (MPLP)

Subcontractors: Mammoth Community Water District (MCWD)

Contract amount: \$1,000,000

Match amount: \$4,571,678

Contractor Project Manager: Robert Sullivan (760) 934-4893

Commission Contract Manager: Pablo Gutierrez S. (916) 654-4663

Project Description: The purpose of this project is to increase power production of the combined geothermal power plants in the Mammoth Pacific Limited Partnership (MPLP) by up to 10 MWe during the summer months. This will be done by modifying the existing power plants to utilize evaporative cooling. The MPLP owns and operates three geothermal binary power plants (G1/G2/G3) with a combined on-line power generation of 32 MWe. Phase 1 testing of this project will include the evaluation of three different evaporative cooling technologies. Phase 2 of this project will construct permanent power plant modifications and the needed support systems to utilize evaporative cooling.

This project supports the PIER Program objectives of:

- Improving energy cost/value of California's electricity by enhancing power generation and improving geothermal power plant efficiency; and
- Improving electricity reliability/quality/sufficiency of California's electrical system by providing up to 10 MWe of power during the summer months.

Proposed Outcomes:

Phase 1 will result in an evaluation of three evaporative cooling technologies to determine their effectiveness in increasing power production from the G2/G3 power plants during the summer months. These technologies include:

1. Swamp Pad Cooler,
2. Spray Bars with Wetted Pads, and
3. Fogger Nozzle.

This evaluation is valuable since summer on-peak power output can be half of the typical winter power output. Lower operation and maintenance costs and ability to maximize power production will be the determining factors in selecting a condenser air-cooling technology. All three technologies will be tested at the G2/G3 power plants.

Phase 2 will result in an engineering analysis and the construction, testing and enhancement of a wastewater conveyance system. The engineering cost analysis will enhance operation and maintenance of MCWD's sewer digester system. Financial considerations include cost of water, long term water availability, wastewater treatment including chemical and biological, operation and maintenance costs, construction and environmental permits, pipeline construction, project financing, capital costs, etc. A permanent pipeline and/or a chemical treatment system will be constructed to supply secondarily treated wastewater from the MCWD sewage treatment facility during the summer months for the G-1/G2/G3 evaporative cooling system.

During the winter months, the pipeline will transport heated wastewater to MCWD's anaerobic digester tank. The wastewater will be heated by waste heat from MPLP's injection brine. The technology will be similar to that of numerous wastewater plants that use the methane gas from anaerobic digesters to heat water, which is sent in a closed loop back to the digester for heating in a heat exchanger.

Project Status:

All activities conducted to date under Phase 1 was financed by MPLP. For Phase 1, the task of determining the impacts from the three evaporative cooling technologies on power plant economics, operations and efficiencies has been completed. Operating parameters have been documented including: power output, turbine back pressure, brine flow, brine temperature, ambient temperatures, actual inlet air temperatures, wind speed, velocity, dew point, dry bulb temperature and air humidity. This information was then compared to historical plant operating data to assess the efficiency of each evaporative media technology. The evaporative cooling media were designed from recorded observations. In addition, MPLP developed a sampling regiment according to U.S. EPA and ASTM lab standards.

Also under Phase 1, MPLP completed an economic analysis to determine the environmental impacts of the reclaimed water from MCWD, the use of geothermal fluid as evaporative cooling fluids, and suitability of silica as a revenue source. The economic analysis also included an assessment of potential hazardous waste disposal under State of California Title V, Hazardous Waste Regulations.

Co-Production of Silica from Geothermal Fluids

Contract #: PIR-00J-003

Contractor: Lawrence Livermore National Laboratory
Subcontractors: US Department of Energy : Mammoth Pacific LP
: Caithness Power : Covanta Power :

Contract amount: \$669,683

Match amount: \$167,420

Contractor Project Manager: William L. Boucier
(925) 423-3745

Commission Contract Manager: Pablo Gutierrez S.
(916) 654-4663

Project Description: The purpose of this project is to develop commercial technologies to efficiently extract silica from geothermal fluids. The extraction of silica will favorably impact the economics of geothermal power generation through the sale of the mineral by-product. Benefits may also be realized from the generation of additional energy and the reduction of operating and maintenance costs at power plants through a reduction in silica scaling. Silica removal reduces the need for costly new injection wells. When left in the reinjected fluids, silica will precipitate in the reinjection pipeline and subsurface rock formations, causing equipment and well plugging. Extracting silica prior to reinjection has no negative environmental impact and allows spent geothermal fluids to be used as a potential source of irrigation or industrial water, rather than reinjected.

This project supports the PIER Program objective of:

Improving energy cost/value of California's electricity by sale of the mineral by-product from geothermal fluids. Benefits may also be realized by the generation of additional energy and the reduction of operating and maintenance costs at power plants through the reduction in silica scaling.

Proposed Outcomes:

This research will develop processes for producing silica from geothermal fluids that are suitable for use in a number of commercial products. Lawrence Livermore National Laboratory's (LLNL) work will focus on studies of the precipitation and post-processing techniques that will result in silica of the appropriate purity, particle size, and surface characteristics for specific industrial uses. The key properties of precipitated silica that must be controlled for it to be useful include: surface area, particle size, and density, pore size, pore size distribution, and degree of agglomeration.

Successfully marketing amorphous silica will require:

1. Matching the physical and chemical properties of silica used in a particular market,
2. Identifying markets that are large enough to absorb the

volume of geothermal produced silica without being overwhelmed, and

3. Obtaining a price for produced silica such that the silica extraction process is economic.

Project Status:

LLNL, in collaboration with Mammoth Pacific Limited Partnership (MPLP), is developing an economical process to extract amorphous silica from spent geothermal fluids.

Activities have included:

1. determining the variables involved in the precipitation process,
2. developing field screening tests,
3. designing tank reactors,
4. prioritizing the precipitation methods to be field tested, and
5. completing the design and performance of the field experiments.

At MPLP facilities, LLNL completed a series of initial field screening tests based on water chemistry data to determine the conditions under which silica best precipitates. The variables included:

1. the addition of salts,
2. the adjustment of pH, and
3. temperature adjustments (cooling).

Based on the findings from the lab and field tests as well as the industrial testing, the conditions of precipitation will be varied as needed to alter the product. In addition, various pre- and post-processing techniques will be applied to the brines and the precipitates as necessary to further optimize the silica properties for industrial use.

Improving Energy Recovery at the Geysers Geothermal Field by Delineation of In-Situ Saturation

Contract #: PIR-00J-004

Contractor: Stanford University

Contract amount: \$258,781

Match amount: \$66,780

Contractor Project Manager: Roland Horne (650) 723-9595

Commission Contract Manager: Gail Wiggett (916) 653-7551

Project Description: The purpose of this project is to develop an understanding of present and past fluid saturation patterns at The Geysers geothermal field, using:

1. Laboratory measurements on actual rock core samples from the reservoir, and
2. Inferring saturations from field production data, by applying

mathematical modeling methods developed at Stanford University.

The Geysers geothermal field is the largest in the world, representing an important fraction of California's electrical power generation capacity. Over the past ten years, energy production from the field has been falling as the reservoir "matures." Recent activities of wastewater injection into The Geysers has indicated that it may be possible to slow if not reverse the decline in energy production. However, the ultimate energy output for electricity generation and the optimal strategy for increased injection of wastewater are uncertain because of the difficulty in determining the distribution and flow characteristic of the underground fluids.

This project supports the PIER Program objectives of:

- Improving energy cost/value of California's electricity by helping to provide reliable base load electric power;
- Improving the environment, public health and safety by providing data that can be used to help maintain electric production from the nation's largest non-hydro renewable energy source;
- Improving electricity reliability/quality/sufficiency of California's electrical system by providing information that will be help to maintain the viability of a major source of renewable energy;
- Strengthening the California economy by using an indigenous energy source within the state; and
- Providing greater choices for California consumers by helping to prolong the life of The Geysers and increasing the availability of "green" power.

Proposed Outcomes:

Production at the Geysers has been in decline in recent years, until large-scale reinjection, notably from the Lake County Sanitation District pipeline, began to renew the resource. An

additional large-scale reinjection pipeline (the Santa Rosa pipeline) is currently being built. Knowing where saturation occurs now and in the past is expected to improve managers' ability to make strategic decisions about operations, future development, and utilization of both large-scale and small-scale injection to rejuvenate the reservoir. The project will also benefit the technical research community by presenting project results in meetings and journals.

Project Status:

The project is presently on schedule. Task 2.1, data compilation, has been completed. This task involved gathering historical records of well pressure, temperature flow rate and enthalpy from wells distributed over The Geysers area. Data from wells over different time periods and different operating units were gathered from public and private sources to provide as complete a snapshot as possible of conditions over time and space in the resource field.

Work is progressing on Task 2.2, data analysis, and in fact is running slightly ahead of schedule. This task involves using a model developed by the Stanford team to infer the historical in-situ water saturation at The Geysers. Using the data from task 2.1 and the model, the goal is to determine the stable initial and dry-out subsurface temperatures for individual wells in the field, and to compute the in-situ water saturation in the vicinity of those wells.

By using wells that started operation over a range of time, the team will be able to infer the evolution of saturated conditions in the reservoir. It also is expected that they will be able to determine the variation in saturation from one area to another within the reservoir. This work involves making calculations of the in-situ saturation for over 500 wells for which they have data records. Task 2.2 is the project's major task.



TrueWind Solutions, LLC**Contract #:** 500-01-009**Contractor:** TrueWind Solutions, LLC**Contract amount:** \$150,000**Contractor Project Manager:** Michael Brower (978) 749-9591**Commission Contract Manager:** Michael Kane
(916) 654-7119

Project Description: The purpose of this contract was to develop more accurate and reliable wind resource maps for California using state-of-the-art numerical modeling techniques and site validation data. This effort not only updates the existing annual wind resource map for California produced in the late 1970s, but it will include several enhancements including the incorporation of new meteorological, geographical and terrain data that have been collected but were unavailable back when the original map was produced. Validation of map results will also be performed in conjunction with the modeling effort. These new maps will help to better define wind corridors as well as identify new potential sites for wind energy integration.

The objective of this effort was to produce high-resolution wind maps of California's complex distribution of wind resources, including nearby offshore areas. Maps showing the mean annual and seasonal wind speed and wind power density on a 400m by 400m grid will be generated in electronic and printed format for multiple elevations above ground level (e.g., 30, 65, and 100 meters). The new map will have a resolution of 400 meters squared in contrast to the existing map that has a resolution of 25 kilometers squared. Because of this, the new maps will show more variability in the wind resources than the old map to better help identify promising areas for wind energy development. The new maps will also use Geographic Information System (GIS) software, overlaying significant features such as power lines, park boundaries, and roads to support future wind energy siting and planning decisions and the evaluation of wind energy development opportunities.

This project supports the PIER Program objectives of:

- Improving energy cost/value of California's electricity by accelerating the initial stages of wind project development with reliable wind maps that substantially reduce risk and siting barriers for new developers;
- Improving electricity reliability/quality/sufficiency of California's electrical system by:
 - providing the most current and reliable information on wind resource data for the state
 - providing data for identifying new potential sites for wind energy integration
 - providing high-resolution wind data useful for forecasting and optimizing wind resource management;
- Strengthening the California economy by encouraging

development of new wind sites and job opportunities;

- Providing greater choices for California consumers by supporting the expansion of clean energy resources and by providing data to make the resources more attractive; and
- Improving the environment, public health and safety by providing the most reliable and updated data for basing decisions and integrating wind technology with existing infrastructure (transmission) and planning strategies.

Proposed Outcomes:

- Updated wind resource maps for California with detailed seasonal and altitude variation data needed for planning and forecasting,
- Access to state-of-the-art numerical modeling technique and expertise to integrate new information in a timely and efficient manner to provide future updates,
- Web accessible new maps that are in a format that can also be immediately integrated with existing State cartography system (GIS format),
- Reliable wind resource data to assist wind project developers, and
- Reliable upper altitude (≥ 50 meters) wind data to assist wind turbine manufacturers in developing safe, efficient and affordable wind turbines

Project Status:

The project was successfully completed on time and under budget. Selected wind maps are available for download (JPG format) on the Energy Commission web site. Hard copies or GIS compatible data files can be ordered from the Commission Cartography Office at 916-654 3902.

Target 84 Renewable Technology Options & Green Power Marketing**84.1 Information to Support High-Value Photovoltaic Power Applications****84.2 Wind Power Development Support****84.4 Biomass Energy****84.5 Renewable Energy Applications in Distributed Generation****Contract #:** 500-00-023 **Project #:** 25-29**Contractor:** Electric Power Research Institute (EPRI)**Project amount:** \$223,449**Match amount:** \$2,792,100**Contractor Project Manager:** Chuck McGowin
(650) 855-2445**Commission Contract Manager:** George Simons
(916) 654-4659**Commission Contract Manager:** Gary Klein (916) 653-8555

Project Description: The purpose of this project is to address the barriers renewable energy technologies face in spite of customer enthusiasm, technology advances, and dropping prices. Still needed are standardized technology and control protocols, more efficient operating strategies, and broader definitions of the true benefits of renewable energy. This EPRI target packages objective information and real-world experience focusing on three main options—wind power, photovoltaics, and biomass. Specifically, EPRI will manage California’s wind energy forecasting project, and broker other collaborative projects with utilities, DOE and others. EPRI will deliver results in areas including biomass cofiring with natural gas, wind power, a renewable energy technical assessment guide, and photovoltaics. This EPRI target provides information on renewable technology performance and costs, analyzes the energy and non-energy benefits of deploying renewable technologies, and offers an inside look at the working experiences of companies around the world.

This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risks of California’s electricity by increasing the potential for application of renewables by providing accurate information on performance, energy and non-energy benefits, costs, and best practices; and
- Improving the reliability/quality of California’s electricity by facilitating the integration of electricity from distributed generation technologies into the State’s electricity transmission and distribution system.

Proposed Outcomes:

1. Produce a technical assessment guide to renewable energy that provides accurate information on technology status, installation history, performance and cost for a range of renewable energy technologies, including photovoltaic, solar thermal, wind, biomass, waste fuels, geothermal, and small hydroelectric systems.
2. Provide guidelines and expert assistance for selecting, designing, and installing cost-effective photovoltaic systems.
3. Provide field wind turbine performance and economic data for advanced early commercial wind turbines that have not been widely deployed.
4. As part of the DOE-EPRI Wind Turbine Verification Program (TVP), conduct an outreach workshop to provide a forum for TVP host utilities, equipment manufacturers, community leaders, and others to discuss the results of the TVP program and lessons learned.
5. Provide information on biomass cofiring projects in the ongoing DOE biomass cofiring field-testing and demonstration program.
6. Collect information and assess the impacts of distributed

renewable energy power generation on the operations and reliability of microgrid systems.

Actual Outcomes:

1. Technical assessment guide on renewable technologies.
 - The *EPRI Renewable Energy Technology Assessment Guide* (TAG-RE) (1004034) was updated and published. The TAG-RE provides comprehensive, detailed information on the technology status, development issues, performance, cost, installed capacity, and markets for renewable technologies. This product is issued in both print and electronic (CD-ROM) formats.
2. Selecting, Designing, and Installing Cost-Effective PV Systems
 - Researchers applied EPRI-developed information on PV and green power markets to case studies of grid-connected PV and PV-hybrid systems to illustrate best practices. Results are presented in a technical report, *Case Studies of Grid-Connected PV Systems* (1004037), published in March 2002.
3. Field Verification of Wind Turbine Performance and Economics – As part of the DOE-EPRI Wind Turbine Verification Program (TVP), EPRI helps transfer the experience acquired in TVP wind turbine projects to turbine vendors, windpower developers, government agencies, utilities, and other interested parties so that the lessons learned can be applied to future projects. To date, EPRI has issued 21 reports on project development and operation for seven DOE-EPRI TVP wind projects located in Alaska, Iowa, Nebraska, Texas, Vermont, and Wisconsin. In 2001, EPRI published the following TVP reports:
 - *Iowa/Nebraska Distributed Wind Generation Projects First and Second Year Operating Experience: 1999-2001: U.S. Department of Energy-EPRI Wind Turbine Verification Program* (1004039).
 - *Kotzebue Electric Association Wind Power Project Second Year Operating Experience: 2000-2001: U.S. Department of Energy-EPRI Wind Turbine Verification Program* (1004040).
 - *Wisconsin Low Wind Speed Turbine Project Third Year Operating Experience: 2000-2001: U.S. Department of Energy-EPRI Wind Turbine Verification Program* (1004041).
 - *Big Spring Wind Power Project Second Year Operating Experience 2000-2001: U.S. Department of Energy-EPRI Wind Turbine Verification Program* (1004042).
4. Annual TVP Outreach Workshop
 - The workshop was conducted and presentation notes published.
5. Biomass Cofiring
 - A technical report – *Annual Report on Biomass Cofiring Program* (1004601) – was published. The report

documents nine years of EPRI/DOE industry engineering analysis and field testing regarding wood and other biomass fuels cofired with coal in utility coal-fired boilers.

6. Distributed Renewable Energy Impacts on Microgrid Systems
- Researchers developed information on the impacts of solar, wind, small hydro, biomass power on the operation, reliability, power quality, emissions, and economics of microgrid systems. Results are presented in a technical report – *Distributed Renewable Energy Generation Impacts on Microgrid Operation and Reliability, Draft Report* (1004045) – published in June 2002.

Project status:

This project is complete.

Program 84 Renewable Technology Options & Green Power Marketing

Contract #: 500-00-023 **Project #:** 60

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$30,750

Match amount: \$503,463

Contractor Project Manager: Chuck McGowin
(650) 855-2445

Commission Contract Manager: George Simons
(916) 654-4659

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of these EPRI projects (500-00-023) is to provide information on the status, performance, and cost of renewable generating technologies, as well as information to support green power marketing. The program supports projects that address field verification and lessons learned in wind, solar photovoltaics, solar thermal, biomass, geothermal, low impact and emerging hydro, and other renewable energy technologies.

This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risks of California's electricity by increasing the potential for application of renewables by providing accurate information on performance, energy and non-energy benefits, costs, and best practices; and
- Improving the reliability/quality of California's electricity by facilitating the integration of electricity from distributed generation technologies into the State's electricity transmission and distribution system.

Proposed Outcomes:

1. Produce a technical assessment guide to renewable energy that provides accurate information on technology status,

installation history, performance and cost for a range of renewable energy technologies, including photovoltaic, solar thermal, wind, biomass, waste fuels, geothermal, and small hydroelectric systems.

2. Develop and deliver information about renewable energy to support public outreach programs, press briefings, presentations and speeches.
3. Conduct field verification evaluations of the performance, cost, reliability, power quality, environmental emissions, and economics of distributed renewable energy generation.

Actual Outcomes:

1. Technical Assessment Guide on Renewable Technologies.
 - The *EPRI Renewable Energy Technology Assessment Guide 2002* (TAG-RE) (1004196) was updated and issued in print, electronic (CD-ROM), and web-based formats. The TAG-RE provides comprehensive, detailed information on the technology status, development issues, performance, cost, installed capacity, and markets for renewable technologies. The 2002 TAG-RE incorporates a shift in emphasis in the PV section from central-station to distributed applications, as a result of projected growth in distributed applications. Because distributed installations require a different economic methodology for estimating costs, the TAG-RE includes new cost calculations based on the Clean Power Estimator. This model was designed by Clean Power Research to provide potential PV owners with an accurate and user-friendly tool for calculating the cost of PV, and is licensed by a number of utilities and public agencies. In addition, TAG-RE users will have access to an online calculation tool. The tool is based on EPRI's TAG calculator, and uses TAG-RE data for wind, central-station PV, and biomass. With the tool, users can run customized cases to obtain cost and performance data.
2. Renewable Energy Information
 - This program publishes EPRI Green Power News (E207557), a bimonthly web-based newsletter that highlights renewable energy technology and market developments.
 - A renewable energy brochure (1004198) was produced that addresses the status and benefits of solar PV, wind, biomass and low-impact hydro resources and technologies, plus green marketing issues for all renewables.
 - A EPRI web-based information service, Renewable Energy Current Information Pages, provides continuous updates on renewable energy technology status, performance, cost, installed capacity, opportunities for project collaboration, and state and federal mandates for renewable energy.
 - A renewable energy slide show (1004199) was prepared that contains presentations on the status and benefits of

solar PV, solar thermal, wind, biomass, and geothermal generation.

3. Field Verification of Distributed Renewable Energy Generation

- The first of a series of technical reports—*Field Verification of Distributed Renewable Energy Generation* (1004205)—was submitted for publication. The report documents results of field verification testing and evaluation.

Project status:

The project was completed in December 2002.

Wind Energy Forecasting Application

Contract #: 100-98-001

Contractor: EPRI

Contract Amount: \$553,504

Contractor Project Manager: Chuck McGowin
(650) 855-2445

Commission Project Manager: George Simons
(916) 654-4659

Commission Contract Manager: Gary Klein
(916) 654-8555

Project Description: The purpose of this project is to develop a California Wind Energy Forecasting System to forecast the hourly wind generation in the state's wind areas. The lack of reliable wind energy forecasts, especially for "next day" conditions, threatens to limit the competitiveness of existing wind plants, as well as constrain future installations. Lacking accurate information, owners and operators of existing plants can incur substantial financial risks when entering competitive bidding for real-time and next-day power supply and ancillary service contracts. Missing these opportunities is devastating for current wind energy suppliers, and a deterrent to prospective investors in new facilities.

The development of an accurate forecasting system could boost private sector investment in wind energy facilities while improving grid operations. Accurate wind forecasting would help wind energy compete with other energy sources in real-time and next-day power markets, and help establish a significant, sustainable role for wind energy in California.

This project supports the PIER program objective of:

- Improving the environmental and public health costs/risks of California's electricity by increasing the use of pollution-free wind energy;
- Improve the cost/value of California's electricity by reducing the risks faced by wind plant owners and operators that offer cost-competitive power;

- Improve the reliability of California's electricity by increasing the likelihood that wind energy will remain a viable and growing source of renewable electricity; and
- Strengthening the California economy by encouraging deployment of new wind plants.

Proposed Outcomes:

Develop and test a wind energy forecasting system that will enable wind generation to effectively compete with other energy sources in real-time and next-day power markets. This is likely to accelerate investment in new capacity, helping establish a significant, sustainable role for wind energy in state and regional generation portfolios.

Actual Outcomes:

In 2001 EPRI executed nondisclosure agreements with host wind project operators, R&D contractors, and meteorological consultants involved in the development and testing of wind forecasting systems at multiple wind plant sites in California. Host agreements were executed with SeaWest, which operates the 66.6 MW Mountain View I and II wind project in the Palm Springs area, and WindWorks/Wind Power Partners 1987 and 1988, which owns 90 MW of Kenetech wind turbines at Altamont Pass. SeaWest and WindWorks/Wind Power Partners' operating unit, PowerWorks, Inc. provided access to daily wind resource and generation data from their respective wind plants. Consulting and R&D agreements were executed with a meteorology consultant and two wind energy forecasting subcontractors.

The project development and test period was delayed about 18 months from the original plan due to delays in obtaining the required historical and daily wind resource and turbine generation and availability data from the wind plant operators. In March 2002, the project scope and cost were reduced to ensure that the project could be completed by December 2002. Two subcontractors generated hourly wind speed and generation forecasts and EPRI evaluated the forecast performance vs. observed data for the Altamont and Mountain View wind projects for the 12-month period, October 2001 through September 2002. The results of the project are documented in two reports, to be published by EPRI and posted on the CEC and EPRI websites during early 2003:

- *California Wind Energy Forecasting System Development and Testing Phase 1: Initial Testing* (1007338).
- *California Wind Energy Forecasting System Development and Testing Phase 2: 12-Month Testing and Evaluation* (1007339).

Project Status:

This project is complete.

**Projects Funded through the
Environmentally-Preferred
Advanced Generation
PIER Program Area**

- Projects Funded in 2002
- Projects In Progress
- Projects Completed



An Integrated Distributed Power System Using a Proton Exchange Membrane (PEM) Fuel Cell and an Autothermal Cyclic Reformer

Contract #: 500-01-022

Contractor: GE Energy and Environmental Research Corporation

Subcontractors: GE Corporate Research and Development, National Fuel Cell Research Center

Contract amount: \$1,959,013

Match amount: \$2,040,987

Contractor Project Manager: Ravi Kumar (949) 859-8851

Commission Contract Manager: Avtar Bining (916) 657-2002

Project Description: The purpose of this project is to develop a pre-commercial prototype for an Autothermal Cyclic Reformer (ACR)-based fuel processor and to integrate the fuel processor with a PEM fuel cell. GE Energy and Environmental Research will design, optimize, and validate a reliable and safe integrated distributed power system based on an ACR and a PEM Fuel Cell that has an electrical efficiency of at least 40% on a lower heating value basis.

This project supports the PIER program objective of:

- Improving the energy cost/value of California's electricity by developing a PEM fuel cell and ACR-based Distributed Power Generation technology that is cost-effective.

Proposed Outcomes:

- The integrated prototype fuel processor will produce a H₂ stream with concentration of CO less than 10 ppm, in order to meet the requirements of the PEM fuel cell;
- The fuel processor will be rated for 50 kW_e;
- The fuel processor will be integrated with a 5-10 kW PEM fuel cell;
- The DPG system will have a system availability in excess of 90%; and
- The DPG system will have an overall electric efficiency greater than 40% (LHV basis).

Expected Benefits:

An installed capital cost of the system of less than \$1,200/kW including a fuel processor cost of less than \$550/kW when the system is manufactured at a rate in excess of 5,000 units per year.

Project Status:

The contract is in place. The project is within budget and on schedule and is expected to achieve its goals and objectives.

Xonon Ultra-low Combustion in Small Multican Turbines

Contract #: 500-01-030

Contractor: Catalytica Energy Systems, Inc.

Contract amount: \$2,997,986

Match amount: \$3,394,304

Contractor Project Manager: Graydon Whidden (650) 934-6598

Commission Contract Manager: John Henry Beyer Ph.D. (916) 654-4609

Project Description: The purpose of this project is to develop a catalytic combustion system that is economically preferred over all other options for achieving exhaust NO_x levels below 3 ppm in a small, multi-combustor gas turbine, without the need for exhaust gas cleanup devices. The intent is to conduct a successful engine test on a gas turbine that is currently marketed commercially. PIER has supported development of the catalytic combustor for single-combustor turbines, so this project will expand the application of this technology to a much broader market that includes multi-combustor turbines.

This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risks of California's electricity by enabling attainment of emissions levels below current regulatory limits, without the need for exhaust cleanup systems, which are more costly and potentially hazardous; and
- Improving the energy cost/value of California's electricity by enabling use of small gas turbines for distributed generation in situations where the cost and footprint requirements of exhaust cleanup systems to meet the mandated emissions levels would be prohibitive, and where there is local resistance to the introduction of toxic chemicals used for exhaust gas cleanup.

Anticipated Outcomes:

NO_x, CO, and unburned hydrocarbon emission levels (at 15% O₂) below 3 ppm, 10 ppm, and 10 ppm, respectively, at simulated loads from 80% to 100% of the turbine's rated power output.

Project Status: This project started in mid-2002, and is ahead of schedule in determining approaches to solve specific technical challenges. The Contractor is finalizing negotiations with a turbine manufacturer to serve as a project partner and work toward an engine test. The project is expected to be completed early in 2005.

Catalytic Combustion Retrofit of a Gas Turbine at Sonoma Development Center

Contract #: 500-01-037

Contractor: California Department of Developmental Services

Contract amount: \$105,000

Contractor Project Manager: Judie Porter
(303) 444-4149

Commission Contract Manager: John Henry Beyer Ph.D.
(916) 654-4609

Project Description: The purpose of this demonstration project is to retrofit a 1.4 MW Kawasaki gas turbine at the Sonoma Developmental Center (SDC) in Eldridge, California, with the Catalytica Energy Systems (CESI) Xonon[®] catalytic combustor which will reduce its NO_x emissions from 30 ppm to less than 2.5 ppm. The project will be the first commercial demonstration of this technology that was developed, in part, with Commission funding. It will provide "real world" performance and operations data on the Xonon[®] technology and allow for comparison of the Xonon[®] -equipped turbine's performance with previous operations under a "no controls" regime and a "Dry-Low-NO_x abatement" regime. The project will also provide the first field demonstration of the Commission's newly developed microturbine test protocols.

SDC is the largest of five facilities operated by the California Department of Developmental Services. There are 800 developmentally disabled clients, plus a staff of 2,500 who provide 24-hour care. The facility encompasses 120 buildings, all of which use electricity and steam provided by a central power plant. This combined heat and power (CHP) system uses waste heat from electricity generation to produce steam to heat buildings, operate sterilizers, and cook food.

This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risks of California's electricity by demonstrating advanced emissions control performance of a small industrial gas turbine operating under commercial conditions, without the use of toxic chemicals for exhaust gas clean-up; and
- Improving the energy cost/value of California's electricity by enabling use of small gas turbines for distributed generation in situations where the cost and footprint requirements of exhaust cleanup systems to meet the mandated emissions levels would be prohibitive.

Anticipated Outcomes:

- Conduct a successful engine test of the ultra-low emissions technology using a small gas turbine model that is currently marketed commercially.
- Demonstrate a catalytic combustion system that is economically preferred over all other commercially available

options for achieving exhaust NO_x levels below 2.5 ppm in a small industrial gas turbine.

Project Status: The Xonon-equipped turbine has been operating virtually nonstop since it was installed in early November 2002, with an average NO_x emission of less than 1 ppm.

Catalytic Combustor-Fired Industrial Gas Turbine

Contract #: 500-01-045

Contractor: Solar Turbines Incorporated

Subcontractors: MRI, Catalytica Energy Systems Inc.

Contract amount: \$2,999,644

Match amount: \$3,435,069

Contractor Project Manager: Kenneth Smith
(619) 544-5539

Commission Contract Manager: John Henry Beyer Ph.D.
(916) 654-4609

Project Description: The purpose of this project is to integrate catalytic combustion technology into Solar Turbine's Taurus 70, a 7.5 MW industrial gas turbine. As part of this project, Solar is working with Catalytica Energy Systems' lean catalytic combustion system, Xonon. A fully operational lean catalytic combustion system will be designed, procured, and evaluated at Solar's facility in San Diego. In parallel, Solar is also evaluating Alzeta's surface combustion and Precision Combustion's rich/lean catalytic combustion technologies. Eventually, Solar will select among the three emission reduction technologies, equip one of their turbines and conduct an engine test.

This project supports the PIER program objectives of:

- Improving the energy cost/value of California's electricity by reducing cost of and environmental barriers to the use of distributed generation. This will reduce electric power costs for the public and private sectors, increase the electric capacity within the state, and enhance the reliability and quality of the state's power infrastructure.
- Improving the environmental and public health costs/risk of California's electricity by reducing emissions from gas turbines and through the creation of superior NO_x reduction technologies.

Anticipated Benefits:

This activity represents a key step in the implementation and commercialization of a <2.5 ppm NO_x combustion technology for California-based turbines. The commercialization of this technology will spur the growth of distributed power

generation and cogeneration in the state by providing a lower cost path to ultra-low NO_x emissions compared to exhaust gas cleanup.

Project Status:

The project is on schedule, and is in the early stages of component and system design, procurement and fabrication.

A Proposal for an Ultra-Low Emissions System Development Project

Contract #: 500-02-002

Contractor: Waukesha Engine, Dresser Inc.

Contract amount: \$2,995,060

Match amount: \$1,570,410

Contractor Project Manager: Steven Lueck (262) 549-2783

Commission Contract Manager: Avtar Bining (916) 657-2002

Project Description: The purpose of this project is to develop and demonstrate a natural gas fueled, reciprocating engine system with emissions reduction technology and fuel reformation that meets the 2007 EPAG ARICE emissions-and-installed cost targets improving efficiency by 20 percent. The developed engine system will provide electrical system reliability, air emission, and economic benefits to the California ratepayers.

The goals of this project are to introduce a new engine emission control technology that will:

- Decrease engine emissions by 90 percent;
- Increase rich burn engine efficiency by 20 percent;
- Reduce installed cost of DG systems by 20 percent; and
- Maintain engine durability at current levels.

This project seeks to capture the high efficiency and extremely low emissions of a lean burn engine equipped with expensive selective catalytic reduction (SCR) after-treatment, while maintaining the excellent cost benefit ratios of rich burn engines using low-cost, readily available three-way catalysts.

The proposed technology improvements focus on NO_x and CO emissions, engine efficiency and cooling, CHP efficiency, cost and engine durability. While there will be no specific work on generator system improvements, a net increase in fuel-to-electric efficiency will be realized reflecting the engine efficiency improvements. No adverse affects are expected on VOCs or particulate emissions.

EPAG targets will be directly addressed by the technology development. By the end of the project in 2005, engine

emissions of NO_x and CO will be lowered by the combination of EGR and fuel enhancement, and a three-way catalyst will further reduce the NO_x and CO to meet the 2007 EPAG targets. In addition to the positive affect on emissions, EGR and fuel enhancement technology will extend the power available from the rich burn engine by 25%, increasing its efficiency by 20% and achieving 95% of the 2005 efficiency target. Installed costs will be lowered through increased engine power and the use of a three-way catalyst instead of a more complex and expensive SCR system. The resulting cost will also come in below the 2007 target.

This project meets the PIER program objectives of:

- Improving the environmental and public health costs/risk of California's electricity by attaining 2007 emissions targets in 2005. Further improvements in air quality will be achievable by retrofitting the developed technology on rich burn engines already in operation; and
- Improving the energy cost/value of California's electricity by raising engine efficiency while lowering installation costs. This will reduce non-renewable energy consumption and total emissions tonnage while lowering the cost of electricity to customers.

Anticipated Benefits:

This project will eliminate \$1000/kW cost of additional emissions control equipment currently required for NO_x mitigation on reciprocating engines, and will provide superior NO_x performance at costs far below the cost of SCR and other alternate NO_x control technologies.

Project Status:

The contract has been approved and is in place. The contractor has begun work. This project is on schedule and within budget.

Low Cost, High Efficiency, Ultra-low NO_x ARICE Solution Using HCCI Combustion

Contract #: 500-02-003

Contractor: Lawrence Livermore National Laboratory

Subcontractors: UC Berkeley

Contract amount: \$1,999,017

Match amount: \$600,000

Contractor Project Manager: Daniel Flowers (925) 422-0529

Commission Contract Manager: Avtar Bining (916) 657-2002

Project description: The purpose of this project is to develop an engine generator set that uses a Homogenous Charge Compression Ignition (HCCI) system and operate the engine generator set for more than 1,000 hours. If successful, this

project will demonstrate a reciprocating engine technology that is the superior distributed generation solution (in terms of emissions, efficiency, and cost) for the below-5 MW market that can be ready for sale in 2005.

This project supports the PIER Program objectives of:

- Improving the energy efficiency and reducing the cost of distributed energy resources;
- Improving the environment, public health and safety by helping reduce electricity generation emissions; and
- Providing products and choices to California consumers for near-term DG applications.

Anticipated Benefits:

This project will eliminate the cost (approximately \$1000/kW) of additional emissions control equipment currently required for NO_x mitigation on reciprocating engines. This will provide superior NO_x performance at costs far below the cost of Selective Catalytic Reduction (SCR) and other alternate NO_x control technologies.

Status:

The contract has been approved and is in place. The contractor has begun work, and the project is on schedule and within budget.

Development of a Partial Oxidation Gas Turbine for Combined Electricity and Hydrogen-Enriched Fuel Gas Production

Contract #: 500-02-005

Contractor: Gas Technology Institute

Subcontractors: Solar Turbines, Eclipse Combustion

Contract amount: \$1,618,084

Match amount: \$1,618,083

Contractor Project Manager: Joseph Rabovitser
(847) 768-0548

Commission Contract Manager: John Henry Beyer Ph.D.
(916) 654-4609

Project Description: The purpose of this project is to develop and demonstrate an ultra-high efficiency, environmentally superior and cost-competitive partial-oxidation gas turbine (POGT) system for combined electricity and high-temperature hydrogen-enriched fuel gas production suitable for application

in a wide range of utility and industrial processes. After development of the 200 kW_e POGT, it will be field tested in combination with an existing industrial boiler or high temperature furnace in California.

This project supports the PIER program objectives of:

- Improving the energy cost/value of California’s electricity by development of a novel approach to using small turbines for on-site, low cost electric power generation that can be readily integrated with existing utility and industrial thermal processes for extremely high overall energy utilization efficiency; and
- Improving environmental and public health costs/risk of California’s electricity by demonstrating the POGT system’s capability to significantly reduce NO_x and CO₂ emissions associated with gas-fired, turbine-based power generation and existing thermal processes.

Anticipated Benefits:

The overall economic/cost objective of this unique combined heat and power (CHP) project is to demonstrate POGT installed capital costs that are competitive with conventional small turbines and overall electricity production costs, including emissions controls that are significantly lower than for existing stand-alone turbines and hybrids. Specific technical and economic performance targets include:

- An increase in overall thermal efficiency of an integrated POGT-furnace system by 40%, and a POGT-boiler system by 25%.
- Fuel to electricity efficiency in excess of 88%.
- NO_x emissions less than 3 ppm (@ 15% O₂) for the POGT, and 50% to 70% reduction for industrial furnaces and boilers.
- Significant CO₂ (a greenhouse gas) reduction by improved efficiency and fuel utilization.

Project Status:

GTI is concluding contract negotiations with subcontractors. The gas turbine to be used for development and testing, a Solar Spartan 350, has been delivered to the test facility.



Low NO_x GT Combustor**Contract #:** 500-00-004**Contractor:** Alzeta Corporation**Contract amount:** \$1,311,768**Match amount:** \$2,740,000**Contractor Project Manager:** Neil McDougald (408) 727-8282**Commission Contract Manager:** Avtar Bining (916) 657-2002

Project Description: The purpose of this project is to continue advancement of Alzeta's Surface Stabilized Combustion technology to build monolithic injectors for application in industrial- and micro-scale gas turbine engines. Development will include formulation of improved monolithic injector design and manufacturing methods, rig testing of the improved monolithic injector in micro- and industrial-scales, and engine testing of the improved monolithic injector in a microturbine generator.

The overall technical goal of this project is to bring to market readiness gas turbine monolithic injector utilizing Surface Stabilized Combustion (SSC) technology. The monolithic injector will be commercialized under the trade name, GTSB.

The specific, technical objectives upon which this project's success will be evaluated are to:

- Successfully cast monolithic injectors, which removes all solid-metal parts from the combustor.
- Successfully develop and demonstration monolithic injectors for microturbine generators manufactured by Honeywell.
- Successfully develop monolithic injectors for industrial engines manufactured by Solar Turbines.
- Produce on-engine emissions performance of < 5ppmv NO_x (15% O₂) and < 10ppmv CO

The overall economic/cost goal of this project is to produce a commercial product which is cost competitive with existing dry low NO_x combustors and superior to Selective Catalytic Reduction (SCR) while providing emissions performance superior to both.

The specific, economic/cost objectives upon which project's success will be evaluated are to:

- Eliminate \$100/kW cost of additional emissions control equipment currently required for NO_x mitigation on industrial-scale engines.
- Provide superior NO_x performance at costs on a par with the best available dry low NO_x combustors for micro-scale gas turbine engines.

This project supports the PIER Program objective of:

- Improving the environment, public health/safety by producing a commercial product which is cost competitive

with existing dry low NO_x combustors and superior to Selective Catalytic Reduction (SCR) while providing emissions performance superior to both.

Anticipated Benefits:

This project will eliminate \$100/kW cost of additional emissions control equipment currently required for NO_x mitigation on industrial-scale engines, and will provide superior NO_x performance at costs on a par with the best available dry low NO_x combustors for micro-scale gas turbine engines.

Status:

This project is on schedule and within budget. The micro-turbine part of this project has been on hold since February 2002 due to Honeywell's decision not to pursue microturbine development.

Integrated Gas Production and Handling System for Renewable Fuel Simulation. (UCI)**Contract #:** 500-00-020 **Project #:** 1**Contractor:** University of California, Irvine**Project amount:** \$991,695**Contractor Project Manager:** G. Scott Samuelsen (949) 824-1999**Commission Contract Manager:** Arthur J. Soinski Ph.D. (916) 654-4674

Project Description: The purpose of this project is to develop a gas production and handling system with the ability to simulate nearly every imaginable fuel gas composition, including fuel gases from renewable and industrial sources, sufficient to operate distributed (DG) systems up to 250 kW in size. The gas production facility will be able to deliver fuel mixtures containing natural gas, nitrogen, carbon dioxide, carbon monoxide and hydrogen. The simulated gas mixtures will be used to test DG systems in Project 2 of this contract.

This project supports the PIER Program objective of:

- Improving the energy cost/value of electricity by creating the ability in California to test DG systems under laboratory conditions on a variety of simulated fuels. Fuel flexibility in DG operation permits the use of biomass-derived and waste fuels that may be less expensive and/or less polluting than natural gas.

Anticipated Benefits:

The anticipated benefit is the ability to test and verify the performance of DG systems on various known fuel compositions that may be encountered in the field without having to operate the systems in the field at a biogas production facility.

Project Status: Project 1

The project is behind schedule because of difficulty in obtaining a production system for hydrogen and carbon monoxide that meets the gas volume requirements within the contract budget.

Develop & demonstrate MTG combustion system capable of operating on medium & low Btu gas and liquid fuels. (UCI)

Contract #: 500-00-020 **Project #:** 2

Contractor: University of California, Irvine

Project amount: \$528,895

Contractor Project Manager: G. Scott Samuelsen

(949) 824-1999

Commission Contract Manager: Arthur J. Soinski Ph.D.

(916) 654-4674

Project Description: The purpose of this project is to develop and demonstrate a Microturbine Generator (MTG) combustion system that is capable of operating on medium-BTU content gas, low-Btu content gas, and liquid fuel.

The Technical Objectives for the MTG combustion system, when used in a modified Capstone Turbine Corporation MTG are:

- <10 ppm NO_x and CO from 50-100% load at 100% rated efficiency on medium- and low-BTU fuels for a range of gas compositions and
- <10 ppm NO_x and CO emissions from 50-100% load at 80% rated efficiency on liquid fuels.

Emission target levels are corrected to 15% oxygen, under International Organization for Standardization (ISO) test conditions. Percent rated efficiencies are in comparison to performance on natural gas fuel.

This project contributes to the PIER program objective of:

- Improving the energy cost/value of California's electricity by demonstrating the fuel flexibility of MTGs. Fuel flexibility without increased atmospheric emissions and loss of fuel-to-electricity would permit MTG operators to use fuels other than natural gas.

Anticipated Benefits:

The anticipated benefits of this project are

- A publicly-available database of the emissions and efficiency of Capstone microturbines operating at part to full load operating on four different fuels:
- natural gas (as the baseline),
- low heat content synthetic gas (similar in chemical composition to that from biomass gasification),

- medium heat content synthetic gas (similar in chemical composition to landfill and sewage digester gas), and
- liquid fuels (such as diesel fuel).
- Validation of certain MTG performance testing protocols developed under Contract #500-99-028, Project 1.
- A demonstration of the fuel flexibility of a MTG that can be used by MTG owners in making decisions about their ability to use backup fuels to natural gas.

Project Status: Project 2

The project is behind schedule because of the problems encountered in Project 1. The project should be completed on schedule by March 31, 2005.

Develop Low NO_x - Low CO MTG Combustor with incremental price increase <20% of standard design

Contract #: 500-00-020 **Project #:** 3

Contractor: University of California, Irvine

Project amount: \$826,917

Contractor Project Manager: G. Scott Samuelsen

(949) 824-1999

Commission Contract Manager: Arthur J. Soinski Ph.D.

(916) 654-4674

Project Description: The purpose of this project is to develop and demonstrate a low emission combustor for a microturbine generator (MTG) that is cost effective. The technical performance objectives are

- Suitability for retrofit installation into a specific MTG or incorporation into new MTG designs
- Target emission levels of less than 3 ppm_v NO_x and 10 ppm_v CO at 15% O₂ for 50-100% load operation on natural gas fuel and during start-stop mode.

- The economic performance objective is an increase in capital cost of no more than 20% above that of a conventional combustor.
- The combustor development is being done in collaboration with Capstone Turbine Corporation, a California-based MTG manufacturer.

This project supports the PIER program objective of:

- Improving the energy cost and value of California's electricity by developing a combustor that will enable the siting of MTGs in accordance with the strictest air quality standards in the nation.

Proposed Outcomes: Project 3

- Develop a MTG combustor that produces emissions of less than 3 ppm NO_x and less than 10 ppm CO at 15 percent O₂

when operating on natural gas over a 50 to 100 percent load range and during start-stop. Determine if the incremental price of MTGs using this combustor can be no more than 20 percent greater than standard designs.

- Estimate the cost of combustor production at a realistic production rate. A successful combustor design will meet the technical and economic performance objectives.

Project Status: Project 3

The project is behind schedule and below budget. The first Critical Project Review has been held, and the project is continuing under a revised schedule. The project should be completed within the contract performance period.

Experimental Study of Jet Mixing in Rich-Quench-Lean Combustors

Contract #: 500-00-025

Contractor: University of California, Irvine

Contract amount: \$269,224

Contractor Project Manager: G. Scott Samuelsen
(949) 824-1999

Commission Contract Manager: Arthur J. Soinski Ph.D.
(916) 654-4674

Project Description: The purpose of this project is to obtain fundamental understanding of the mixing and reaction processes involved in the Rich-burn/Quick-mix/Lean-Burn (RQL) combustion concept. The RQL concept is one technique for obtaining low NO_x emissions from gas turbine combustors. Lean premixed combustion systems can achieve low NO_x and CO, however, combustion becomes unstable at the leanest conditions than minimize emissions. The RQL concept is believed to have the ability to reduce unstable combustion conditions. The success of RQL depends on the mixing of air jets in the combustor's quick-mix section with the fuel-rich gases coming from the Rich-burn section. The Contractor is performing experimental studies in the field of jet mixing at the high-temperature, high-pressure combustion conditions found in gas turbines. The detailed spatial characterization of the thermal and chemical flow fields coupled to modeling efforts will aid in optimizing the Quick-mix section for low NO_x formation without operation under conditions that are susceptible to combustion instability.

This project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by developing a robust combustor that produces few pollutants and that avoids combustion instability. Low NO_x and low CO combustors will facilitate siting gas turbines in California without the need for post-combustion emission reduction technologies.

Proposed Outcomes:

- Characterization of the temperature and emissions fields within the jet-mixing section.
- Understanding the means by which NO_x and CO are produced in the mixing section and relate this insight to the overall performance of the RQL combustor.

Project Status:

The project is on schedule and on budget. The Test Plan and design of the experimental facilities have been completed. The experimental facilities construction is nearly complete.

Ultra-Low NO_x Combustion System for a 13.5 Mw Gas Turbine Generator

Contract #: 500-01-010

Contractor: Alzeta Corporation

Subcontractors: Solar Turbines, Inc.

Contract amount: \$2,404,310

Match amount: \$1,076,510

Contractor Project Manager: Neil McDougald
(408) 727-8282

Commission Contract Manager: Avtar Bining
(916) 657-2002

Project Description: The purpose of this project is research and development in the area of ultra-low emissions combustion control for gas turbine engines. This project fits into a continuum of ultra-low emissions developments in previous PIER contracts with Alzeta (500-97-031 & 500-00-002). The work under this contract includes combustor materials and manufacturing development, lab testing, engine testing, and field demonstration of the low NO_x gas turbine combustor system. The results of this contract will help California's need for distributed generation capacity without sacrificing environmental quality considerations.

This project supports the PIER Program objectives of:

- Improving the environment, public health and safety by accelerating development of an ultra-low NO_x combustion system; and
- Improving the energy cost/value of California's electricity by reducing the capital cost of ultra-low NO_x gas turbines and providing competitive technology for ultra-low emissions.

The overall technical objective of this project is to develop an ultra-low NO_x combustion system for the Solar Turbines Titan 130 gas turbine and demonstrate successful its successful operation. The specific technical and economic performance goals of this project are as follows:

- < 3 ppm NO_x emissions,
- 10 ppm CO emissions,

- 10 ppm UHC emissions,
- 26,000 hours serviceable life, and
- Incremental cost of less than \$150,000 per engine.

The specific, economic/cost objectives upon which project's success will be evaluated are to:

- Eliminate \$100/kW cost of additional emissions control equipment currently required for NO_x mitigation on industrial-scale engines.
- Provide superior NO_x performance at costs on a par with the best available dry low NO_x combustors for micro-scale gas turbine engines.

Anticipated Benefits:

This project will eliminate \$100/kW cost of additional emissions control equipment currently required for NO_x mitigation on industrial-scale engines, and will provide superior NO_x performance at costs on a par with the best available dry low NO_x combustors for micro-scale gas turbine engines.

Status:

This project is on schedule and within budget. The project end-date is October 2003.

The Testing, Optimization & Demonstration of an (EPAG) Microturbine

Contract #: 500-01-012

Contractor: ALM Turbine, Inc.

Subcontractors: Optimized Turbine Solutions, Alturdyne, Parametric Solutions, SoCal/Sempra, University of California, Irvine, Oak Ridge National Labs, Atlantic Precision

Contract amount: \$2,867,270

Match amount: \$3,405,443

Contractor Project Manager: Boris Glezer (858) 481-5977

Commission Contract Manager: John Henry Beyer Ph.D. (916) 654-4609

Project Description: The purpose of this project is to use a combination of novel technologies to improve the performance of a 300 kW microturbine. The technologies include the following:

- A new, low-cost recuperator;
- Advanced blade cooling strategies;
- Combustion methods to control the formation of polluting emissions; and
- Power turbine designs that cut mechanical losses.

The project will analyze the performance of prototype systems, upgrade their designs, proof-test the upgraded designs in a prototype engine, and then build three beta test engines for laboratory and field testing.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by fostering the use of distributed generation (DG) in a way that will increase local electricity supply reliability, reduce costs and reduce peak demand on the power grid;
- Improving the reliability/quality of California's electricity by developing and demonstrating a microturbine with significantly increased efficiency at both full load and part load, high reliability, and increased power quality; and
- Improving environmental and public health costs/risk from California's electricity system by reducing emissions from microturbines used as a distributed energy resource.

Proposed Outcomes:

- Thermal efficiency at full load increased from 24-30 percent to 37.5-40 percent.
- Part-load efficiency of at least 30 percent at 15 percent power and relatively high efficiency over a power range of 50-400kW.
- Emissions of <5 ppm NO_x, <20 ppm CO and no unburned hydrocarbons (UHC).
- Availability of >90 percent with a life of 40,000 hours and mean time between overhauls of 15,000 hours.
- High responsiveness to sudden load and speed changes.
- The elimination of a number of life-limiting parts found on many gas turbines.
- A turbine geometry that can be used for a family of engines from 75kW to 500kW.
- Multi fuel capability (three premiums and one bio-derived).
- Cost range of \$500-600 per kW.

Project Status:

This project will commence in the first quarter of 2003 upon completion of predecessor R&D work. Project completion is anticipated in mid-2005.

A 500 kW Zero-Emission Gas-Fired Power Plant

Contract #: 500-01-013

Contractor: Clean Energy Systems, Inc.

Subcontractors: Mirant Delta : Air Liquide :

Contract amount: \$2,003,286

Match amount: \$2,045,931

Contractor Project Manager: Ronald Bischoff (916) 379-9143

Commission Contract Manager: John Henry Beyer Ph.D. (916) 654-4609

Project Description: The purpose of this project is to demonstrate the long-term reliability and durability of a unique

fossil-fueled, zero-emission power generation system based on rocket engine designs. The unique gas generator produces high-temperature, high-pressure gas composed almost entirely of steam and CO₂. Oxygen is used to combust the fuel, rather than air as in conventional systems, thereby eliminating the formation of NO_x and the large volume of non-condensable exhaust gas. The high-energy gases drive a steam turbine that, in turn, drives a conventional electrical generator. For this demonstration project, a 500 kW gas generator will be built and operated for two years to produce electricity at a Mirant power plant in Antioch, California.

A demonstration of this type is essential before utilities will be willing to risk using a new technology. The CES technology is unique and innovative, and could be a revolutionary power generation breakthrough. Public benefits from use of the CES technology at power plants could be substantial. Air emissions would be negligible. Exhaust from the gas generator is water, most of which is recycled, and nearly pure CO₂, which can be sequestered or used commercially, e.g., for enhanced oil recovery from existing oil fields. When, in the future, CO₂ sequestration is required or a carbon tax is imposed, a CES power plant would be considerably more efficient than a modern gas-fired, combined cycle power plant.

This project supports the PIER Program objective of:

- Improving the environment, public health and safety by accelerating the development of fossil fuel electricity generation system with nearly zero emissions and the option of CO₂ sequestration.

Proposed Outcomes:

- One year of non-stop operation of the CES system to demonstrate long term reliability.
- A second year of operations under various off-design conditions to characterize the performance of the system, demonstrate durability and establish acceptable operating limits.

Project Status:

This demonstration project started early in 2002 as scheduled. Completion is anticipated in late 2005.

Reduced Temperature SOFCs Operating on Direct Oxidation of Natural Gas

Contract #: 500-01-014

Contractor: Lawrence Livermore National Laboratory

Contract amount: \$3,000,000

Match amount: \$6,000,000

Contractor Project Manager: Robert Glass (925) 423-7140

Commission Contract Manager: Arthur J. Soinski Ph.D.
(916) 654-4674

Project Description: The purpose of this contract is to develop a commercially viable planar solid oxide fuel cell (SOFC) system with high reliability, high power density, low degradation rate, and high efficiency.

SOFCs operate at 1,000°C (1,832°F). The high temperature is dictated by the need for high ionic conductivity of the electrolyte, which is achieved only at higher temperatures. The high temperature of operation and the need to cycle between ambient temperature and operating temperature causes thermal stresses on the fuel cell components with consequent crack formation.

Lower operating temperatures would permit the replacement of certain ceramics with metals with resultant advantages in terms of cost, ease of fabrication and durability. However, suitable alternative materials must be identified and fabrication methods must be developed.

Most lower temperature SOFCs have inadequate power density to be commercially viable. Power density (which is the ratio of output power to the volume of the fuel cell stack) is an indicator of manufacturing cost, with higher power density translating into lower cost. LLNL has demonstrated high power density in a single cell operating at 800°C in three-cell stacks. LLNL has also developed the colloidal spray deposition process, a low-cost manufacturing technology.

The project supports the PIER Program objectives of:

- Improving energy cost/value of California electricity by reducing the manufacturing cost and by improving the efficiency of solid oxide fuel cells;
- Improving reliability and sufficiency by developing a distributed generation technology that can operate on different fuels and that can be sited in buildings in urban areas; and
- Improving the environment and public health by generating electricity with carbon dioxide and clean water as the only significant emissions.

Proposed Outcomes:

- An integrated fuel cell system that meets all economic and field application requirements.
- A metal cell interconnect that is highly conductive and is compatible with other fuel cell components.
- New sealant materials that connect piping to the fuel cell stack without leakage.
- New materials, designs and fabrication techniques for the

electrolyte, anode and cathode. Demonstration of a single cell with a peak power density greater than 0.7 W/cm² at 650°C.

- An improved proprietary stack design achieved by means of computer modeling. Simulation of stack operation, including thermal, mechanical, and electrochemical parameters. Identification of the strengths and weaknesses of various system design approaches.
- An anode that directly oxidizes hydrocarbon fuels without the need for a separate reformer.
- Achievement of a \$800/kW cost target for a complete SOFC system.
- Successively larger fuel cell stacks, culminating in a 10 kW stack. The 10 kW stack will be integrated with a complete balance of plant system and the integrated system will be operated evaluated as a stand-alone generating system.

Project Status:

The Contractor began work. Work has been temporarily halted pending resolution of a Stop Work Order issued because a key subcontractor was unable to obtain funding for \$6,000,000.

Design, Construction, and Operation of a Power Module for High Efficiency, Low-Cost, Multi-Fueled 10-100 kW Solid Oxide Fuel Cells

Contract #: 500-01-020

Contractor: Gas Technology Institute

Subcontractors: Materials and Systems Research Inc., Nexant Inc., University of Utah, Technologic Corp.

Contract amount: \$2,999,998

Match amount: \$1,309,204

Contractor Project Manager: Kevin Krist (847) 768-0793

Commission Contract Manager: Arthur J. Soinski Ph.D. (916) 654-4674

Project Description: The purpose of this project is to design, fabricate, operate and test a 3 kW sub-scale solid oxide fuel cell (SOFC) stack and balance of plant that have potential for low cost and high efficiency. The sub-scale module consists of a fuel cell stack, air pre-heater and pre-burner. The module will be the basis for 10-100 kW SOFC systems suitable for distributed generation cogeneration applications.

The project team will achieve high efficiency through several design features including rectangular fuel cells radiating heat to an air pre-heater panel adjacent to the stack, even flow and temperature distributions in a cross flow stack, low air-to-fuel ratio, and low pressure drop across the stack. Material and energy balances for the design indicate a potential for a natural gas-to-electricity conversion efficiency of 55 percent with an additional 35 percent of the fuel heat content available as high quality heat.

The project supports the PIER Program objectives of:

- Improving energy cost/value of California electricity by reducing the manufacturing cost and by improving the efficiency of solid oxide fuel cells;
- Improving reliability and sufficiency by developing a distributed generation technology that can operate on different fuels and that can be sited in buildings in urban areas; and
- Improving the environment and public health by generating electricity with carbon dioxide and water as the only significant emissions.

Proposed Outcomes:

- Materials and material combinations that have the potential to achieve a cell power density of at least 0.7 W/cm² operating on hydrocarbon fuels at 650°C.
- A fuel cell stack with a power density of 0.4 W/cm² at 0.8V operating at 650°C. The fuel utilization target is 60-85% and the air utilization target is equivalent to 50% excess air.
- Power degradation of <0.6% per 1,000 hours for the 1-3 kW power module during 2,000 hours of operation near the design point.
- Operation of three sub-scale power modules that have heat transfer, multi-fuel capability, reliability and thermal and load cycling performance for 50% electrical efficiency in 10 kW systems.
- Verification that a three-dimensional stack model can accurately predict stack performance effects associated with parameters such as stack dimensions, reactant flow pattern, radiation heat transfer, volumetric power density, and secondary cooling effects.

Project Status:

The project is on schedule and on budget.

Catalytic Combustor - Fired Industrial Gas Turbine for Distributed Power & Cogeneration Applications

Contract #: 500-98-041

Contractor: Solar Turbines Incorporated

Contract amount: \$814,543

Match amount: \$773,391

Contractor Project Manager: Kenneth Smith (619) 544-5539

Commission Contract Manager: John Henry Beyer Ph.D. (916) 654-4609

Project Description: The purpose of this project is to develop the necessary component technologies and complete

engineering design of a multi-can catalytic combustion system suitable for application in two gas turbines, the Taurus 60, rated at 5.2 MW, and the Centaur 50, rated at 4.6 MW. The system will be designed for 5-ppm NO_x emissions without the use of water or steam injection or the use of any post-combustion NO_x reduction. This project is the first of three phases of development. Phase two will conduct hot testing of the combustor assembly. Phase three will test the combustor in actual operation on a gas turbine.

This project supports the PIER Program objectives of:

- Improving the reliability and quality of California's electricity by eliminating harmful pollutants and allowing these gas turbines, to be used in distributed generation applications;
- Improving the energy cost/value of California's electricity by introducing industrial gas turbines with catalytic combustion, rather than the higher-cost option of post-combustion treatment systems such as selective catalytic reduction (SCR); and
- Improving the environment and public health cost/risks of California's electricity by incorporating pollution prevention that is potentially more effective at reducing NO_x and CO emissions than post combustion pollution clean-up.

Proposed Outcomes:

- Bring to market readiness, a catalytic combustion system that is cost competitive with other commercially available NO_x reduction technologies for industrial scale gas turbines.
- Lab test to develop and then integrate the optimum preburner, premixer, catalytic core and burn out zone liner designs into the Centaur 50 and Taurus 60 gas turbines.
- Implement a control system strategy for the catalytic combustion system capable of handling start-up, shutdown, load following, and full load loss without damage to the combustor or gas turbine.
- Produce a commercial product that provides cost effective NO_x control that meets permitting requirements in the most restrictive air quality districts.
- Capital cost over eighty percent less than selective catalytic combustion systems for the Taurus and Centaur gas turbines with comparable NO_x control. This will result from completion of this three-phase project.

In its efforts to use a catalytic combustion system on its Taurus 60 and Centaur 50 industrial gas turbines, Solar has delivered reports describing progress in developing the necessary component technologies and engineering designs for the pre-burner, fuel-air premixer, catalytic core, burnout zone liner, engine hardware, and control system. Solar has also written a preliminary production readiness plan.

Project Status:

This project is being terminated ahead of schedule due to changes in the direction of Solar's research efforts. As a result, there have been minor scope reductions in some tasks, and one task concerning experimental evaluation of combined premixer and pre-burner performance was not undertaken. Task reports describing the R&D work accomplished have been submitted to the Commission, and the final report is expected by March 2003. Solar is building upon all of the knowledge gained in this contract and is continuing these efforts to implement ultra low emissions technology in its gas turbines in a follow-on Commission contract (#500-01-045) entitled *Catalytic Combustor-Fired Industrial Gas Turbine*.

Demonstration and Testing of Microturbine Generators. (UCI - APEP)

Contract #: 500-99-028 **Project #:** 1

Contractor: University of California, Irvine

Project amount: \$604,866

Contractor Project Manager: G. Scott Samuelson
(949) 824-1999

Commission Contract Manager: Arthur J. Soinski Ph.D.
(916) 654-4674

Project Description: The purpose of this project is to develop standardized performance testing and reporting procedures or protocols for microturbine generators (MTGs). Standardized protocols are being developed for heat rate or fuel-to-electricity conversion efficiency, atmospheric and acoustic emissions, and power quality.

The technical performance goals are to:

- Form and use a stakeholder group to identify appropriate parameters for inclusion among the testing protocols and to review project deliverables; and
- Develop a set of prescriptive testing and reporting methodologies that will result in uniform testing and reporting of MTG operation under specified operating conditions.

The economic performance goal is to:

- Accelerate the market penetration MTGs by providing common methods for performance testing and reporting of test results.

These projects support the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing standardized MTG performance data that can be used by manufacturers to improve their products; and

- Improving the environmental and public health costs/risks of California's electricity by providing standardized methods for measuring and reporting atmospheric emissions.

Anticipated Benefits:

Standardized testing and reporting procedures for MTGs will:

- Provide consistent MTG performance information regardless of who performs the testing
- Allow comparison between manufacturers' specifications and actual operation; and
- Indicate technology barriers limiting performance of MTGs and thereby identify opportunities for future research, development and demonstration.

Project Status:

Technical work is complete with the exception of the Final Report. The term of the contract is August 2, 2000 to June 30, 2004.

Development of Steady-State Analytical Tools for Fuel Cells. (UCI - NFCRC)

Contract #: 500-99-028 **Project #:** 2

Contractor: University of California, Irvine

Project amount: \$306,322

Contractor Project Manager: G. Scott Samuelsen
(949) 824-1999

Commission Contract Manager: Arthur J. Soinski Ph.D.
(916) 654-4674

Project Description: The purpose of this project is to develop steady state computer simulation modules and analysis strategies for fuel cell and fuel cell/turbine hybrid systems and cycles. Simulation modules for higher temperature fuel cells, namely solid oxide and molten carbonate fuel cells, and associated balance of plant components for fuel cell and fuel cell/turbine hybrid systems, will be developed and integrated into a computer code. A graphical user interface and a web-based version of the code will be developed.

The project is a continuation of work started under a previous PIER Contract #500-98-052.

This project contributes to the PIER program objective of:

- Improving energy cost/value by applying the predictive capabilities of the analysis tools to guide future fuel cell and fuel cell hybrid system design and operation.

Anticipated Benefits:

The anticipated benefit is a publicly-available computer code that incorporate a fundamental understanding of the processes and features of fuel cell systems. The code will predict system performance the effects of system design and operational changes on performance. The code will permit manufacturers to determine how to construct fuel cell and hybrid systems in order to reduce complexity while retaining reliability and reducing cost.

Project Status:

The project is on budget and on schedule.
The term of the contract August 2, 2000 to June 30, 2004.

Dynamic Modeling of Fuel Cells and Hybrid Systems. (UCI - NFCRC)

Contract #: 500-99-028 **Project #:** 3

Contractor: University of California, Irvine

Project Amount: \$497,979

Contractor Project Manager: G. Scott Samuelsen
(949) 824-1999

Commission Contract Manager: Arthur J. Soinski Ph.D.
(916) 654-4674

Project Description: The purpose of this project is to develop computer simulation modules to describe the dynamic operation of fuel cell and fuel cell hybrid electricity generating systems. Modules will be developed that describe the dynamic operation of a solid oxide fuel cell, a molten carbonate fuel cell, a gas turbine engine, a fuel reformer, and the balance of plant for a fuel cell/turbine system. Dynamic operation includes system start-up and shutdown, electric load following, a change in fuel flow, composition, temperature or pressure, a change in gas turbine inlet and outlet conditions, and change in turbine rotation speed. Data will be collected to verify the validity of the computer simulations.

This project contributes to the PIER program objectives of:

- Improving energy cost/value by developing the predictive capability of fuel cell and hybrid system operation so as to guide future generating system design.

Anticipated Benefits:

The anticipated benefit is a publicly available computer simulation that accurately describes the performance of a fuel cell or hybrid system during dynamic operating conditions. The simulation will substitute for physical testing and will be especially useful as a substitute for physical testing under

conditions that could damage system components. The simulation will permit the screening of hybrid system designs, probing of the operating space of current and future designs, evaluating component changes, and aiding in correcting operating problems.

Project Status:

The project is on schedule and on budget. The term of the contract is July 15, 2000 to July 15, 2004.



TARGETS 63.0/23 EMERGING DISTRIBUTED RESOURCE TECHNOLOGIES; 63.1 IC ENGINE DEVELOPMENT FOR DR APPLICATIONS; 63.4 FUEL CELL DISTRIBUTED POWER SYSTEMS

Contract #: 100-98-001

Contractor and Major Subcontractors: EPRI; Power Computing Systems; Proton Energy Systems; Hpower; American Fuel Cell Corporation; NYSEG; International Fuel Cell; TMI; MSRI; SCE; Chugach Electric Assoc.; SDG&E; American Electric Power

Contract Amount: 1999: \$249,250
2000: \$179,400

Match Funding: 1999: \$3,796,885
2000: \$3,301,088

Contractor Project Manager: Dan Rastler, (650) 855-2521

Commission Project Manager: Jairam Gopal, (916) 654-4880

Commission Contract Manager: Gary Klein, (916) 653-8555

Project Description: The purpose of this project is to promote the potential that distributed energy resources (DER) have to provide a substantial portion of the energy alternatives now demanded by California electricity users. Both energy service providers and customers need accurate and unbiased information on the benefits and liabilities associated with commercially available and emerging distributed resource technologies. DER technologies offer third-party energy service providers and energy customers innovative solutions to their energy service needs.

EPRI's Emerging DER Technologies target provides detailed information on commercially mature reciprocating engines and gas turbines, and emerging microturbines and fuel cell systems technologies. To gather this information, EPRI assesses advanced DER components, performs technology validations, and leads pre-commercial development on technologies that offer high pay-off. As a member, the Energy Commission will obtain intelligence in three distinct areas: rapid changes in technology, development of new distributed resources, and post-R&D commercialization initiatives. This target examines a balanced portfolio of near, intermediate, and long-term options.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers;
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power; and
- Improving the environmental and public health costs/risks of

California's electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

1. Provide unbiased accurate information on emerging DER technologies to increase customer choice and enable competition.
2. Provide information and assistance toward the resolution of cross cutting issues that generally slow the adoption process.
3. Bring to market readiness fuel cell technologies that include polymer electrolyte membrane (PEM) fuel cell systems and ultra-high efficient solid-oxide fuel cells (SOFC).
4. Accelerate the development of spark-ignited and micro-pilot, dual-fuel natural gas engines with major engine manufacturers for commercial applications in the 600 kW to 2 MW size range.
5. Conduct a Tailored Collaboration entitled "Workshop on Environmental Impacts of New Generation in California" to inform the public debate on the environmental effects of new generation options.
6. Conduct a Tailored Collaboration entitled "Emissions Testing and Certification Guidelines for DG Generators" to reduce the time and cost of DG technologies to meet existing and future emissions regulation.

Actual Outcomes:

1. Unbiased accurate information.
 - *Assessment of Distributed Resource Technologies* (TR-114180) was published.
 - Bench and field tests were conducted on PEM fuel cells and microturbines, and detailed technology assessments—including data on performance, emissions, and power quality characteristics—were published as *50 kW PEM Fuel Cell System Design, Fabrication, and Test: System Design -- Final Report* (1000771).
 - A state-of-the-art assessment - *Assessment of Small Reciprocating Engine Manufacturers and Generator Set Packages* (1000766) - was produced on internal combustion engines for electric generation applications.
 - A market study report - *Distributed Generation Market Study: Advanced Turbine System Program* (TR-112174) - was published on advanced turbines.
 - Intelligence Reports—quarterly reports on the latest breaking information on DER technologies—were published.
 - DER technologies were evaluated through site visits and meetings with leading manufacturers, and results were published in quarterly reports and technical reports.
 - An annual national DER conference was organized, providing a forum for utilities, energy companies,

equipment manufacturers, and vendors to discuss the latest technology, market, and policy developments.

2. Resolution of cross-cutting issues.
 - A report - *Gas Turbine Recuperators: Benefits and Status* (TR-113745) - was published on the benefits and status of gas turbine recuperators.
 - A report - *Assessment of Emission Control Technologies for Distributed Resource Options* (TR-113743) - was published on emission control technologies for DR options.
 - The performance of a 7-MW gas turbine for transmission and distribution grid support and a residential fuel cell were evaluated.
3. Fuel cell technologies.
 - An advanced solid oxide fuel cell (SOFC) system was successfully tested. Test results were summarized in a report - *Demonstration of a High Efficiency Solid Oxide Fuel Cell-Microturbine Hybrid Power System: Interim Report: Factory Testing* (1000751).
 - A technology assessment of residential power systems - *Technology Assessment of Residential Power Systems for Distributed Generation* (TR-113897) - was published.
 - An assessment was published of fuel-processing technology for fuel cells, - *Hydrocarbon Reformers for Fuel Cell Systems* (TR-113742).
 - A report evaluating 100-kW to 300-kW SOFC systems was published.
 - A bottom-up assessment of planar SOFC technologies was conducted, investigating the details of the cell, stack, subsystem, and balance-of-plant. A report - *Reduced-Temperature, Anode-Supported, Planar Solid Oxide Fuel Cell Systems: Product Definition* (1000773) - summarized results.

- A report was published on factory test data and on market and economic analysis of 5-kW residential power generators.
 - A report - *50 kW PEM Fuel Cell System Design, Fabrication and Test: Utility/User Interface Issues* (1000750) - was published on an analysis of a 50-kW PEM system for commercial applications.
4. Natural gas engines.
 - A report - *Reciprocating Engines for Stationary Power Generation: Technology, Products, Players, and Business Issues* (TR-113894) - was published on reciprocating engines for stationary power generation.
 5. A workshop entitled "*Workshop on Environmental Impacts of New Generation in California*" was held in San Diego in October 1999, and a final report was published.
 6. The scoping study was completed and a report - *Emissions Testing and Certification Guidelines for Distributed Generators* (1007452) - was published.

Project Status:

This project is complete.



**Projects Funded through the
Energy-Related
Environmental Research
PIER Program Area**

- Projects Funded in 2002
- Projects In Progress
- Projects Completed



Development of Indoor and Ambient Portable Air Monitors

Contract #: 500-01-031

Contractor: California Air Resources Board (CARB)

Contract amount: \$500,000

Contractor Project Manager:

Commission Contract Manager: Kelly Birkinshaw
(916) 654-4542

Project Description: The purpose of this collaborative project is to develop and demonstrate one or more portable, inexpensive, real-time ambient air monitor(s) capable of characterizing ambient air quality for power plant siting, including distributed generation (DG) units and environmental justice (EJ) considerations. The California Energy Commission, the CARB, and the New York State Energy Research and Development Authority (NYSERDA) are participating in this effort.

Several studies have shown that minority and low-income communities overall are exposed to more environmental hazards, and power plant emissions can constitute one aspect of exposure. Environmental justice is a matter that is addressed at both the federal and state levels, and these evaluations are a part of California's power plant licensing process. The monitors currently in use are too expensive to purchase, install, operate, and maintain to provide the desired air monitoring coverage for these applications, therefore, new, portable, easier-to-use and less-expensive monitors must be developed for this purpose.

This project will also develop at least one portable indoor air monitor that can be used to obtain better information on the impact of energy-related activities on indoor air quality (IAQ). Indoor air concentrations of many pollutants can be many times higher than outdoor levels. The ambient air monitor will focus on criteria pollutants whereas the indoor monitor may focus on toxins.

Researchers have conducted a scoping study that identified priority pollutants that need to be monitored. The Energy Commission is particularly interested in measuring PM₁₀ and PM_{2.5}, O₃, NO_x, SO₂, and volatile organic compounds (VOCs), because they are contained in (or result from) power plant emissions. Project researchers have also identified and evaluated instruments and technologies suitable for ambient and indoor air monitoring, including: existing monitoring instruments and technologies, instruments and technologies under development, instrument and technology gaps, and organizations with the expertise to bridge those gaps.

This project supports the PIER program objective of:

- Providing environmentally sound and safe electricity by

enabling Energy Commission staff and others to conduct site-specific siting and EJ analyses in any location where the need arises and to provide the analyses to the appropriate decision-makers.

Proposed Outcomes:

- Researchers and regulators will be able to use portable ambient air monitors to monitor ambient air at the location of proposed power plants, which will improve confidence in monitored data quality and enhance Commission siting decisions.
- By reducing the cost of monitors and the need for trained technicians, portable monitors may be able to reduce instrumentation and operation costs significantly.
- Indoor air monitors could improve public health by measuring levels of indoor air pollutants and identifying problem locations.
- On-site monitoring will enhance the ability of California's air districts to determine emissions in ambient and indoor air from distributed generation technologies.

Project Status:

A Request for Proposals to develop and demonstrate portable monitors was released and 13 proposals have been received. These proposals are in review by the staffs of the CEC, CARB and outside experts.

Avian-Transmission System Mitigation Program

Contract #: 500-01-032

Contractor: Regents - Santa Cruz

Contract amount: \$1,000,484

Contractor Project Manager:

Commission Contract Manager: Linda Spiegel
(916) 654-4703

Project Description: The purpose of this program is to conduct research for the development and application of methods and technologies for reducing and resolving negative impacts from avian interactions with utility structures. Electricity is transmitted throughout California via hundreds of thousands of miles of distribution and transmission lines. Avian interactions with these lines can be beneficial (by providing nesting and perching sites and migration corridors) or detrimental (by causing collisions, electrocutions, and habitat fragmentation). Collisions with, and electrocutions by power lines can be biologically significant when they affect a bird population's ability to sustain or increase its numbers locally or throughout its range.

Although research has been conducted to help document the problems nationwide, little is known about the statewide significance of these impacts, and solutions are still pending. Significant progress had been made in the last decade to understand causes of electrocution and collision risk, however, many solutions are still unproven or have proven ineffective. For example, marking devices designed to increase line visibility have been developed, but the efficacy of each design is not well known and needs further studies. Furthermore, devices designed to insulate electrocution points on distribution lines have been developed, but a recent study found that 37 percent of the devices installed were defective and ineffective, while 65 percent were installed improperly. Retrofitting lines to make them more bird-friendly is considered highly cost prohibitive by utilities. Providing tools to aid in the identification of problem poles would considerably reduce retrofitting costs.

This project supports the PIER program objectives of:

- Improving the energy cost/value of California’s electricity by reducing costs associated with avian-caused power outages and retrofitting transmission systems with bird-friendly designs;
- Improving the environmental costs/risk of California’s electricity by providing effective tools to reduce avian fatalities from interactions with transmission systems; and
- Improving the reliability and quality of California’s electricity by reducing the number of power outages caused by avian interactions with transmission systems.

Proposed Outcomes:

- Develop tools, technologies, and protocols to evaluate, mitigate, and reduce avian-utility structure problems.
- Reduction of avian fatalities and electrical outages caused by avian electrocution and collisions with utility structures.
- Improve system reliability and compliance with State and federal laws protecting most birds.

Project Status:

The first request for proposals was released on January 13, 2003. A total of \$500,000 will be awarded to projects that address research issues identified in PIEREA roadmaps on avian power line electrocution and collision in competitive solicitations, sole source requests, and graduate research.

Short Range Dispersion Study

Contract #: 500-01-038

Contractor: California Air Resources Board (CARB)

Contract amount: \$436,516

Contractor Project Manager: Tony Servin (916) 323-5122

Commission Contract Manager: Kelly Birkinshaw (916) 654-4542

Project Description:

The purpose of this project is to improve air dispersion modeling so that elevated and ground-level urban power plant emissions can be modeled accurately over short distances to support environmental justice (EJ) evaluations and to account for the increased use of distributed generation (DG) technologies in California.

In 2002, the California Energy Commission and the California Air Resources Board (CARB) co-sponsored a workshop to evaluate the performance of existing, short-range dispersion models. Experts on short-range dispersion modeling from state and federal agencies, university and private research organizations, and private companies identified the limitations of these models and proposed research that would enable modelers to conduct more accurate and reliable short-range modeling.

This project addresses concerns expressed at the workshop, and builds upon work by the CARB and the University of California at Riverside (UCR) that is developing an algorithm to estimate the impact of near ground-level urban emissions sources at distances of tens of meters to a few kilometers from the source. The algorithm will be designed for incorporation into models such as AERMOD (a commonly used dispersion model), to improve the accuracy of dispersion modeling in urban areas. The project is also developing a model evaluation database from tracer experiments that have been conducted in several urban areas.

This project will:

- Develop a dispersion algorithm for ground-level (e.g., from distributed generation units) and elevated sources (e.g., from power plant stacks) in urban areas. This algorithm will account for changes in dispersion patterns caused by the urban environment and the land/sea locations in which many power plants in California are placed. It will also account for how ground level and elevated releases tend to disperse during different times of the day, particularly in urban areas.
- Conduct tracer gas studies with sulfur hexafluoride (SF₆), including capturing and analyzing SF₆ concentrations downwind of a ground level and an elevated release.
- Evaluate the dispersion algorithm with the tracer field data.
- Use tracer data to evaluate a proposed dispersion model that may be able to better model inhomogeneous power plant plumes (that is, emissions in non-uniform, more turbulent air).
- Evaluate the performance of the ISCST3, AERMOD, and CALPUFF microscale models—as well as a Lagrangian particle dispersion model being developed at UC Riverside that will provide concentration estimates at very short distances (in scales of meters to tens of meters from a source).

Modeling results from this project will be shared with EPA's Emission Modeling and Analysis Division, which is currently developing guidelines for air dispersion modeling of toxic pollutants in urban areas.

This work addresses issues identified in the PIEREA Distributed Generation and Environmental Justice roadmaps. It also addresses the Governor's environmental justice directives, as well as the commitment of the Energy Commission and ARB to environmental justice issues.

This project supports the PIER program objectives of:

- Providing environmentally sound and safe electricity by improving the accuracy of emissions dispersion models will enable regulators and power producers to address health issues stemming from power plant emissions; and
- Improving the reliability of California's electricity with increased use of distributed generation sources. This project will improve the ability of regulators and communities to evaluate where this equipment can be placed safely, which could speed its implementation and contribution to the State's electricity system.

Proposed Outcomes:

- Regulators can use these models for EJ determinations, to help determine whether emissions from a proposed power plant could present an undue risk to populations in adjacent areas. This work will improve a modeler's ability to determine impacts from power plant emissions in urban areas.
- Air districts will be able to use these models to determine the emissions contribution of DG technologies.

Project Status:

The contract for this project has recently been approved. Contract activities are scheduled to start on schedule.

Ecological Impacts of Pulsed Flows from Hydroelectric Facilities

Contract #: 500-01-044

Contractor: University of California, Davis (UCD)

Contract amount: \$987,024

Contractor Project Manager: Douglas Conklin
(530) 752-7601

Commission Contract Manager: Joe O'Hagan
(916) 653-1651

Project Description: The purpose of this project is to develop a scientific framework for assessing possible short and long-term ecological impacts of pulsed flow releases on California

stream systems regulated for hydropower production. The majority of the state's hydropower capacity is in facilities that use water impoundments, such as dams. These peaking facilities can discharge stored water to generate electricity almost instantaneously during peak demand periods. This flexibility is a crucial asset in the state's electricity system. The ability to dispatch electricity with little notice is a great asset to the reliability of California's electricity grid, however, the abrupt and abundant release of water from hydropower plants into the rivers and streams below them -- a technique know as "pulsed flows" -- affects the aquatic habitats and organisms that live in those water bodies.

How specific flows affect aquatic habitats and their inhabitants is a matter of considerable uncertainty. The lifecycles, habitat needs, and environmental control factors governing behavior are poorly understood for many aquatic species, which makes it difficult for hydro plant operators and regulators to balance flows in a way that protects the long-term viability of native and recreational fisheries while maximizing power production. Moreover, this uncertainty results in a failure to realize the full economic and recreation potential of stream resources, a failure to protect aquatic communities, or both.

Specifically, PIER and the Center for Aquatic Biology and Aquaculture (CABA) at UCD will develop a technical advisory group consisting of agency, utility, and stakeholder representatives. This advisory group will:

- Review the quality and availability of scientific data on the ecological impacts of pulsed and manufactured flows on California stream habitats and biotic communities.
- Determine whether current sampling, analytical and mitigation methods are adequate to detect, predict and resolve potential effects of pulsed flows from load-following hydroelectric, recreational and sediment management releases on aquatic habitats and biotic communities.
- Examine the suitability of new/different sampling and analytical methods to detect and predict potential effects of recreational flow, and load-following hydroelectric releases on aquatic habitats and communities.
- Based upon these assessments, identify and prioritize research that is needed to improve sampling, analysis, mitigation and monitoring of the ecological effects of pulsed and manufactured flows on freshwater habitats.
- Evaluate research proposals and products awarded under this project.
- Develop and disseminate results to other agencies, researchers, and industry.

CABA will prepare a request for proposals under the direction of the advisory groups and manage the awarded contracts.

This project supports the PIER program objectives of:

- Providing environmentally sound and safe electricity. This work will help improve and maintain the health and safety of aquatic environments associated with hydro plants by helping operators and regulators prevent adverse effects on downstream aquatic life and habitats;
- Improving the reliability of California's electricity by better understanding the effects of water releases on downstream organisms and habitats. This work may improve the ability of many of California's hydroelectric facilities to respond to peak electricity demand thereby increasing electricity system reliability; and
- Improving the energy cost and value of California's electricity by preventing lasting effects on the structure and function of aquatic ecosystems, this work will help maintain the value of aquatic habitats for both native and recreational fisheries.

Proposed Outcomes:

- Understanding how pulsed and manufactured flows impact sensitive species and aquatic communities will allow stream managers and regulatory agencies to effectively tailor flows for maximum electricity, economic, recreational and environmental benefits.

Project Status:

This project was approved in the fourth quarter, 2002 and project activities are scheduled to begin.

California Environmental Sensing and Communications

Contract #: 500-02-004, WA-MR-002

Contractor: University of California, Office of the President

Project amount: \$147,000

Contractor Project Manager: Dan Cayan

Commission Contract Manager: Guido Franco
(916) 654-3940

Project Description: The purpose of this project is to develop new environmental sensors that will be used to start collecting California meteorological and hydrological data at a high profile, remote location in the state. In recent decades, streamflow records collected at relatively low elevation suggest that an alarming shift toward earlier snowmelt has been occurring in the Sierra Nevada, a possible impact of global warming. This trend can lead to increased danger of floods in the winter season, lower availability of water during the summer, and less reliable hydropower production. Unfortunately, due to the high cost and difficulty of data collection, there is a lack of data that are necessary to detect, understand, and evaluate the impacts of this trend.

To address these problems, this project will develop a relatively low-cost sensor/data logger/transmitter system. This system will be designed to measure key meteorological and hydrological parameters such as:

- snow cover;
- precipitation levels;
- wind velocity;
- humidity;
- temperature;
- solar radiation; and
- temperature.

Once developed, the system will be deployed in Yosemite National Park. Subsequent projects will result in the installation of more monitoring systems in remote locations and/or high elevations, areas of the state that are poorly covered with existing monitoring technology.

This project supports the PIER program objectives of:

- Improving the environmental and public health cost/risks of California's electricity by designing and constructing a low-cost meteorological/hydrological data logging/sensing hardware that can be installed in remote locations; and
- Improving the reliability, quality, and sufficiency of California's electricity by gathering the data that will allow, in the future, the evaluation and enhancing of regional climate and hydrologic models. These models will allow the state to better manage its energy and water resources.

Proposed Outcomes:

- Develop non-intrusive and less expensive remote monitoring systems to substantially increase the number of monitoring sites and monitoring parameters for measuring key regions of the state.
- Install these monitors in Yosemite National Park.
- Provide public access to the data on the Energy Commission's PIER Website.
- Minimize the economic and societal impacts of climate change to California.

Project Status:

Project activities are scheduled to start in January 2003.

Integrated Forecast and Reservoir Management Demonstration for Northern California

Contract #: 500-02-008

Contractor: Hydrologic Research Center (HRC)

Subcontractors: Georgia Water Resources Institute: Dr. Aris Georgakakos

Contract amount: \$300,000

Match amount: \$755,795

Contractor Project Manager: Konstantine Georgakakos
(858) 794-2726

Commission Contract Manager: Joe O'Hagan (916) 653-1651

Project Description: The purpose of this project is to demonstrate an approach to improving runoff forecasting and reservoir management in Northern California with the aim of maximizing, with existing infrastructure, hydropower production and water supply. California's in-state hydropower facilities constitute 27 percent of its generation capacity and supply the state with an average of 15 percent of its electricity each year. However, the amount of electricity that a hydro plant can generate in any given year is based on California's variable climate (which determines the amount and timing of rainfall and snowpack runoff) and competing municipal, agricultural, and environmental needs.

Although the amount of rainfall and snowpack can differ greatly from year to year, both electricity and water demand continues to climb. To generate as much power as possible from hydroelectric facilities, managers must be able to estimate the most efficient use of water on a daily, weekly, monthly, and yearly basis. In this three-year effort, PIEREA and the Hydrologic Research Center will implement an ensemble of a forecasting system that will provide reservoir managers daily, weekly, and monthly probability estimates for runoff, based on historic and simulated data.

To implement these runoff forecasts, the project will develop a decision support system to assist reservoir managers to balance hydropower production and water supply needs with other needs such as flood control and instream flows. This Integrated Forecast and Reservoir Management Demonstration (INFORM) will be conducted at the Folsom, Oroville, Shasta, and Trinity reservoirs. Based on data collected from these sites, researchers will quantify improved water management efficiencies and document forecast and management methodologies and models.

In the first phase of the project, researchers will simulate runoff probabilities for the upstream watersheds for the four reservoirs. This will be achieved through the use of historic data and simulations of runoff conditions with global climate models. A major effort of this phase of the project will involve the testing and validating of methods to downscale information from global climate models to a scale suitable for the hydrologic forecast models.

The project will also develop an interlinked Sacramento River Decision Support System (SRDSS) of models for the four reservoirs, including an integration of climate and an ensemble

of hydrologic upstream forecasts and long-range decision modeling for the entire Sacramento system. To facilitate the evaluation of impacts from reservoir site release decisions, researchers will assemble and formulate hydrologic models as needed for the downstream Sacramento River.

Once the SRDSS has been used and validated, researchers will develop and include a policy assessment model in the system. The model will quantify the system response for a specified inflow sequence, streamflow forecasting scheme, and operational policy. At the completion of the forecast-decision-simulation process, the program will generate sequences of all relevant system performance measures, including reservoir levels, releases, energy generation, flood stages, instream flow conditions, and water supply deficits, if any. These sequences could be used to compare the benefits and consequences of various inflow scenarios, forecast-decision configurations, and operational policies.

This project supports the PIER program objectives of:

- Providing environmentally sound electricity. Improved runoff forecasting and reservoir management will provide for increased hydropower production and water supply without additional environmental damage. In addition, electricity produced by hydropower generation displaces the need for electricity that would otherwise most likely be generated by fossil-fuel generating plants;
- Improving the reliability of California's electricity. The development of better water use forecasting will enable hydropower plant managers to maintain or even increase hydropower production at California hydropower facilities. Using this fuel-free, in-state source bolsters the state's energy reliability and independence. Hydropower can also be put online quickly, which can help alleviate shortages elsewhere; and
- Providing affordable electricity by increasing the efficiency of hydropower plants. Hydroelectric generation is among the lowest-cost means of generating electricity, and this project will help California maintain its supply of this inexpensive, environmentally-clean source of electricity.

Proposed Outcomes:

- Hydroelectric power plant managers will have better information which will aid them to estimate the most efficient use of water on a daily, weekly, monthly, and yearly basis, because water use analyses will account for climate variability.

Project Status:

Initial efforts on this project began in the fourth quarter 2002. Contract start-up activities are underway.

Greenhouse Gas Emission and Metrics**Contract #:** 500-00-021**Contractor:** Lawrence Berkeley National Laboratory**Contract amount:** \$228,000**Contractor Project Manager:** Richard Wilson
(510) 486-7391**Commission Contract Manager:** Guido Franco
(916) 654-3940

Project Description: The purpose of this project is to fulfill the mandate(s) in Senate Bill (SB) 1771 and its subsequent amendments that require the California Energy Commission to provide technical assistance to the California Climate Action Registry. This registry, created by the same Senate Bill, allows California entities to register their annual greenhouse gas (GHG) emissions. The Commission contracted with Lawrence Berkeley National Laboratory (LBNL) to generate research products that the Commission needs for the preparation of technical recommendations to the Registry.

LBNL has developed GHG emission allocation rules to estimate indirect carbon dioxide (CO₂) emissions associated with the actual consumption of electricity. The goal is to create and test a set of methods that fairly allocate emissions, taking into account the amount and time of consumption and resource mixes of electricity providers. The methodology will distinguish between in-state and out-of-state electricity generation.

The project will also develop metrics and conduct case studies of three California companies to examine the effectiveness of the metrics. These metrics could be used to compare emission trends between similar companies and to estimate the emissions that would have occurred if the companies did not implement measures to reduce their GHG emissions.

This project supports the PIER program objective of:

- Improving the environment and public health costs/risks by providing the methods needed to allocate CO₂ emissions from electricity consumption and metrics to track progress in reducing GHG emissions.

Proposed Outcomes:

This project will create multiple benefits for regulators, GHG producers, and Californians by:

- Encouraging participation in the Registry. Standard and clear methodologies will encourage the participation of California entities in this voluntary program.
- Provide real world experience with the use of metrics in the state before the Registry allows companies to use metrics to track and report emissions.

Project Status:

This project is underway and nearly complete. LBNL has submitted draft reports and the final report for this project will be submitted by March 2003.

Backup Generators/Distributed Generation Air Quality Methodology Study (Phase II)**Contract #:** 500-00-032**Contractor:** University of California, Riverside**Contract amount:** \$1,500,000**Contractor Project Manager:** James Lents (909) 781-5742**Commission Contract Manager:** Kelly Birkinshaw
(916) 654-4542

Project Description: The purpose of this project is to develop a methodology to assess and quantify the air quality impacts of Backup generators (BUGs), and verify that methodology on the BUGs now operating in California. This project will also estimate the air quality impacts of recent rolling blackouts and identify particulate matter (PM) reductions from use of emissions controls. The project will focus primarily on BUGs, but the methodologies developed will be applicable for analyses of more general distributed generation (DG) technologies when and where appropriate.

Diesel exhaust is a complex mixture of inorganic and organic compounds that exist in gaseous, liquid, and solid phases. Over 90 percent of the mass of these particles are less than 2.5 microns in diameter. Because of their small size, these particles are easily inhaled into the bronchial and alveolar regions of the lung. Diesel exhaust includes over 40 substances that are listed as hazardous air pollutants (HAPs) by the U.S. EPA and by the California Air Resource Board (CARB) as Toxic Air Contaminants (TACs). In addition, the CARB has identified PM from diesel fuel engines as toxic air contaminants and found that long-term occupational exposures to diesel exhaust were associated with a 40 percent increase in the relative risk of lung cancer.

Researchers are conducting field tests of BUGs to collect important baseline emissions data and operating BUG units with alternative fuels and PM exhaust after treatment technologies to quantify the potential benefits from these fuels and technologies. The project is also reviewing already developed BUG inventory data. These data are being used in atmospheric modeling to assess the air quality impacts of BUGs. This effort is being coordinated with CARB.

This project supports the PIER program objective of:

- Improving environmental and public health costs/risk from California's electricity system by providing quantifiable, objective data for decision makers concerning potential

adverse air quality impacts from the use of significant numbers of BUGs. It will also provide appropriate data for decision-makers concerning techniques to mitigate likely air quality impacts associated with the use of BUGs and the effectiveness and durability of PM controls in reducing emissions.

Proposed Outcomes:

- Proven methodologies will promote a clean environment and public health. Standard methodologies will enable regulators and researchers to improve the environmental and public health aspects of generating California's electricity through sound evaluations of PM emission control technologies, air quality impacts of BUGs and other DG technologies.
- Greater use of appropriate DG technologies. Determining how these technologies can be used and dispatched to generate more power with less environmental impact will support the implementation of these technologies in California, which will increase overall generation capacity in the state.

Project Status:

Work has commenced on baseline emissions testing of BUGs and developing the modeling to estimate the air quality impacts of BUGs. The Advisory Committee continues to provide technical direction. The project is proceeding as planned.

Air Quality Impacts of Distributed Generation

Contract #: 500-00-033

Contractor: University of California, Irvine

Contract amount: \$698,689

Contractor Project Manager: Brian Morris (202) 778-8538

Commission Contract Manager: Kelly Birkinshaw
(916) 654-4542

Project Description: The purpose of this project is to determine the regional and overall environmental impacts of widespread distributed generation (DG) implementation in southern California. Researchers will develop and analyze DG implementation strategies that will meet the estimated 20 percent of new load DG market share by the year 2010 and evaluate the associated air quality impacts of using these technologies. This work will also determine whether accurate accounting of aerosol dynamics is required for air quality modeling of southern California and whether the accuracy of state-of-the-art air quality models is sufficient to capture the impacts of DG. Researchers will share the findings with regulatory agencies to facilitate the development of future control strategies.

The application of distributed generation technologies to the California market could bring about important benefits in overall electricity reliability, cost, and power quality, and could potentially reduce overall generation emissions. In 2001, the California Public Utilities Commission developed the \$125 million-a-year Self-Generation Incentive Program to give cash incentives to California business and individuals that begin using DG technologies in the state. Moreover, the Energy Commission projects that between 300 and 400 MW of DG units will be installed in the state in the near term. However, moving from central generation units to localized distributed generation facilities would result in significantly different emissions profiles, with increased and widely dispersed stationary source emissions closer to residential areas.

Project Objectives:

- Establish Distributed Generation Scenarios to represent various emissions portfolios that would characterize DG deployment in 2010 and future years.
- Produce a modeling strategy that can adequately estimate the impacts of DG resources and coordinate with previous and current CARB studies.
- Improve particulate matter (PM) simulations by increasing the level of physical/chemical detail in the aerosol modules.
- Produce aerosol modules or sub-models that could be transferred to other modeling systems such as Model 3.
- Qualitatively estimate the potential impacts of different DG deployment scenarios on efforts to attain the ambient air quality standards for ozone and PM.

The current effort seeks to address these issues and collaborate with the SCAQMD and the CARB to assess the potential impact of DG on air quality.

This project supports the PIER program objectives of:

- Improving environmental and public health costs/risk by enabling researchers to determine how DG technologies should be implemented to reduce environmental impacts by examining various DG implementation scenarios, and
- Improving the reliability/quality of California's electrical system by increasing the ability of California to generate adequate electricity supplies. Identifying how these technologies should be operated as part of the state's generation mix may speed their installation and increase the ability of California to generate adequate electricity supplies.

Proposed Outcomes:

- Improved assessment of potential impacts from DG implementation in southern California. The implementation scenarios studied for this research will enable stakeholders to better understand the impacts on the environment and on

the California electricity system, both from a greater use of DG technologies and from a shift away from centralized generation to distributed generation.

- Improved understanding of air quality modeling for southern California. The role of aerosols in modeling air quality is not yet clearly understood. This work will clarify that role, thus improving the accuracy of air quality modeling for California and the rest of the world.
- DG regulations based on sound science. This work will help regulators develop appropriate regulations for the more widespread implementation of DG.

Project Status:

An Advisory Committee was formed and is providing technical direction to the project. Work has commenced on development of DG scenarios and a modeling strategy to estimate the impacts of DG resources. Project is on schedule, on budget and is expected to achieve proposed outcomes.

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

Contract #: 500-01-019

Contractor: BioResource Consultants

Contract amount: \$420,670

Contractor Project Manager: Carl Thelander (805) 646-3932

Commission Contract Manager: Linda Spiegel
(916) 654-4703

Project Description: The purpose of this project is to complete the avian fatality surveys in areas of the Altamont Pass Wind Resource Area (APWRA) not previously surveyed and to develop a model to identify and reduce collision risk to birds in the APWRA. Such a model will be a valuable tool for siting new or repowered turbines so that reductions in bird fatalities are achieved. Once repowering has occurred, the project will also investigate the effects of these larger, more efficient turbines.

The collision of birds with wind turbines has been documented since the early 1980's and recent findings conservatively estimate that at least 1,000 or more birds, mainly raptors, are being killed annually. Laws protecting birds include the Migratory Bird Treaty Act, the Bald Eagle and Golden Eagle Protection Act, and the federal Endangered Species Act. Violations can result in fines from \$100,000 to \$500,000. Also, Alameda County will not approve additional permits to increase current electricity production at the APWRA until significant progress toward solving the bird fatality issue is demonstrated. Efforts to repower the Altamont Pass and other wind resource areas in the state with larger, greater megawatt capacity turbines have begun without quantifying the effects of these

turbines on birds or a thorough understanding of whether they will reduce bird fatalities.

From 1998 to 2001, BioResource Consultants (BRC), under contract to the National Renewable Energy Laboratory (NREL), has been investigating bird fatalities at the APWRA. According to this work, about 25 percent of the turbines are responsible for 100 percent of the fatalities. It appears that certain topographic features, prey density, and turbine placement factors contribute to avian collision. BRC is applying these data to develop a risk sensitivity model that can be used to determine locations within the APWRA of high, moderate, and low risk to birds. To date, only a small portion (20%) of the APWRA has been surveyed. Additionally, the area surveyed to date does not contain the turbine type that is most abundant in the APWRA.

This project supports the PIER program objectives of:

- Improving the energy cost/value of California's electricity by siting the new, more efficient turbines in low risk locations, resulting in fewer bird fatalities and more megawatts per turbine and reduced maintenance costs;
- Improving the environment, public health and safety by developing a tool that can provide a realistic and cost effective solution to the bird collision problem; and
- Providing greater choices for California consumers by providing a tool that can show a significant reduction in turbine-caused avian fatality, thereby allowing Alameda County to approve permits for an increase in productive capacity.

Proposed Outcomes:

- Determine the extent of avian fatalities associated with the new, larger (repowered) turbines at the APWRA.
- Develop a sensitivity model that predicts fatality risk at particular locations within the APWRA.
- Assist wind industry and the County of Alameda to bring the APWRA into compliance with state codes and federal laws pertaining to existing violations.

Project Status:

Funding for this project began February 2002. BRC is conducting surveys and collecting data on turbine design, turbine placement, topographical features, and prey density at sites with and without fatality incidents. Surveys should be completed in April 2003, a risk assessment model will be completed in May 2003 and a detailed report will be available in June 2003.

Analysis of Aircraft Data from Plume Studies during 2000 Central California Ozone

Contract #: 100-98-001 **Project #:** 40

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$140,000

Contractor Project Manager: Naresh Kumar (650) 855-2990

Commission Contract Manager: Kelly Birkinshaw/Marla Mueller (916) 654-4894

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to analyze ozone production from power plant nitrogen oxide (NO_x) emissions in California. Ground-level ozone (smog) is formed when volatile organic compounds (VOCs) present in ambient air react with NO_x. Exposure to smog can cause or contribute to a number of respiratory problems. Because combined-cycle, gas-fired electric power plants emit NO_x, it is important to measure the correlation between the amount of NO_x emitted and the amount of ozone created, to determine the impact of power plants on ground-level ozone formation. Determining ozone potential efficiency (OPE), which is the amount of ozone formed per unit of NO_x emitted, can help clarify the relationship between power plant emissions and ozone production.

PIEREA and EPRI are analyzing the Central California Ozone Study (CCOS) data collected from the Pittsburg and Moss Landing power plants and their plumes over the summer of 2000. By estimating the ozone potential efficiency of the NO_x emissions from both plants researchers will gain insight into the role that power plants play in contributing to California's ozone problem. The analysis of the extensive power plant plume data collected during the CCOS is important because it is the first data set to test the plume chemistry in the absence of significant amounts of sulfur oxides (SO_x). The Pittsburg data allows researchers to analyze the chemical evolution of a power plant plume in a background dominated by the urban plumes from San Francisco and other nearby urban areas. The Moss Landing data allows researchers to analyze the chemical evolution of a power plant plume in a very clean marine environment.

Until this time, all of the work on ozone production from power plant NO_x emissions has been conducted on the East Coast. This project represents the first comprehensive study of ozone production from power plants plumes in California. This West Coast effort is important because each region has its own distinct set of power plant fuels, geography, climate, and volatile organic compounds, all of which can play a role in ozone formation. The physical and chemical behavior of the plumes will be simulated using the model SCICHEM. A comparison of modeled and observed parameters will be used

to improve model assumptions and algorithms.

This project supports the PIER program objective of:

- Providing environmentally sound electricity by establishing a quantitative association between power plant emissions and ozone production, which will help to develop environmentally sound regulations.

Proposed Outcome:

- Increased knowledge on the effects of power plant emissions on the formation of ozone. The determination of ozone potential efficiency and other parameters from the Moss Landing and Pittsburg power plants will significantly enhance understanding of the impact of power plant plumes on ozone levels in California. It will also contribute to the future Energy Commission air quality modeling work to be conducted with California Air Resources Board (CARB).

Actual Outcomes:

In 2001 CCOS data were examined and rates of formation and removal of NO_x species calculated, relative to the sum of all species. The data analysis suggests that under the conditions of the Moss Landing and Pittsburg plumes, the chain termination process overwhelmed the chain propagation process, leading to NO_x-to-nitrate or nitric acid formation, but no net production of ozone in the plumes.

In 2002, EPRI contracted with Atmospheric & Environmental Research, Inc. (AER) to evaluate SCICHEM using the plume measurements from Moss Landing and Pittsburg power plants. The 3-dimensional model outputs were not available, so it was decided to run the 3-dimensional model using the inputs that were available from ARB. These included emissions inputs prepared by ARB and the meteorological input data files created using MM5 without using the four-dimensional data assimilation. According to Saffet Tanrikulu of CARB, 3-dimensional model performance using these inputs was poor. However, it was decided to use these inputs nevertheless because of unavailability of anything else.

The results from the SCICHEM evaluation with COCS 2000 aircraft plume measurement show that the model does not explain the observed plume data at downwind distances larger than 10 km. The model performance was better for the morning plume traverses than for the afternoon traverses. It is likely that the poor performance of the model is due to errors in the model inputs. The meteorological inputs used in this study are preliminary and are believed to have large uncertainties and errors. There were also interference with urban plumes and mobile source NO_x emissions during the afternoon traverses for both the Pittsburg and Moss Landing plumes that made it difficult to compare model results against

the observation because SCICHEM only predicted the signature from the power plant plume.

Given the poor performance of the model using the currently available inputs, it will be useful to repeat this study when more accurate meteorological and emissions inputs are available later.

Status:

This project is on-going.

Cooling Tower Water Quality Parameters for Degraded Water

Contract #: 100-98-001 **Project #:** 41

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$140,000

Contractor Project Manager: Kent Zammit (650) 855-2097

Commission Contract Manager: Joe O'Hagan
(916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to conduct a literature review to reexamine cooling water quality standards in the context of current practices and to develop new water quality parameters that consider the most current information and treatment approaches.

Given the increasing demands on California's limited water supplies, power plant operators are turning to degraded water sources for power plant cooling. Degraded water sources are water supplies that are not readily suitable for most other uses because they contain naturally occurring or human-induced pollutants. Such water sources include effluent from wastewater treatment plants, naturally occurring brackish groundwater, and surface and groundwater bodies contaminated by pesticides, solvents, and other pollutants. Although some types of degraded water supplies have been used for power plant cooling, the use of such sources raises unique concerns for power plant operators. Even when using the best quality water, cooling water chemistry must be closely monitored to avoid corrosion, scaling and biofouling. Using degraded water for cooling only heightens these concerns to plant operators.

Recommended current cooling water quality criteria do not specifically address the use of degraded water supplies, the use of newer technologies such as high-efficiency "film-pack" fills, nor the tendency to increase the number of times that water is cycled through the cooling tower.

This work includes an assessment of cooling tower systems that use high-efficiency "film pack" fills in conjunction with the use

of recycled or reclaimed waters at higher cycles of concentration. The final report will recommend techniques that power plant operators can use to maintain water quality while also optimizing cooling system operation and reducing harmful impacts to aquatic organisms.

This project meets the PIER program objectives of:

- Providing environmentally sound electricity by bringing cooling water quality criteria up to date and ensuring that they address the use of degraded water supplies, newer cooling technologies, and greater cycling of water through cooling towers. Greater use of degraded water for power plant cooling can conserve California's limited freshwater supplies for other, more appropriate uses.
- Providing reliable electricity by potentially decreasing incidences of corrosion or fouling in cooling systems, resulting in less frequent maintenance outages. By determining and recommending appropriate water quality parameters, power plant operators can reduce downtime and increase electricity production.

Proposed Outcome:

- Minimal environmental impact from power plant cooling water. Establishing up-to-date water quality parameters will help ensure that power plants minimize their environmental impact on associated water bodies.

Project Status:

A literature review was completed in 2001. A report on the results of this work was issued in July 2002. EPRI has also funded the development of a water quality calculator to be included with the report. The calculator will assist users in analyzing their water quality to determine optimal treatment approaches. The project will be complete by early 2003.

Technology Assessment of Electrotechnologies

Contract #: 100-98-001 **Project #:** 42

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$220,000

Match amount: \$110,000

Contractor Project Manager: Keith Carns (314) 935-8598

Commission Contract Manager: Joe O'Hagan
(916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to assess various environmental electrotechnologies under development, assess their commercialization potential and possible impact on California's economy, and recommend a selected number of technologies worthy of further funding by the California Energy

Commission.

Some electrotechnologies, such as reverse osmosis and ozonation, are well established and commercially available. Others, such as radiofrequency (RF) drying and electron beam irradiation, are less mature and further development is necessary to bring these technologies to market. As environmental regulations tighten in response to public health and ecosystem concerns, industries must seek improved methods to control or remediate pollution. In order to more effectively appropriate resources to the most promising and applicable emerging technologies, it is important to develop a good understanding of the potential performance and cost of electrotechnologies designed for environmental protection.

To facilitate the use of effective electrotechnologies, PIEREA and EPRI are assessing a variety of options under development in the United States, specifically focusing on those that show particular promise for use in California. The resulting report will describe the technical and economic status of these emerging electrotechnologies, offer projections of their future performance and costs, and make recommendations for appropriate use of any developmental funding supplied by the CEC.

This project supports the following PIER Program objectives of:

- Providing environmentally sound electricity by expanding the use of electrotechnologies that can be used for environmental control in a variety of industrial processes. Their expanded use can potentially reduce the waste stream from power plants (as well as other industrial facilities); and
- Supporting the development of new electricity applications to solve environmental issues by using the evaluation of the efficacy of electrotechnologies to help industries mitigate their impacts on the environment.

Proposed Outcomes:

- Increase the use of beneficial electrotechnologies in California. This assessment will enable the Energy Commission to effectively target future research into improving the economic and public benefits of environmental electrotechnologies.
- Promote improved treatment of industrial emissions. Electrotechnologies can replace treatments using potentially harmful chemicals, reducing the amount of chemicals released by industrial facilities, including power plants.

Actual Outcomes:

- The contractor developed a list of approximately 45 promising electrotechnologies along with a set of criteria to quantitatively rank them. Detailed evaluations of the

technologies, research needs, and projected costs were developed for the most promising technologies.

Project Status:

The draft final report on the results of this work has been submitted to the Commission for its review and feedback.

Monitoring System for Studying Avian and Wildlife Interactions with Power and Communications Facilities

Contract #: 100-98-001 **Project #:** 47

Contractor: Electric Power Research Institute (EPRI)

Subcontractors: EDM Inc.

Project amount: \$100,000 (2001/02)

Match amount: \$100,000 (2001/02)

Contractor Project Manager: Rick Carlton (650) 855-2115

Commission Contract Manager: Linda Spiegel (916) 654-4703

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to mitigate and reduce avian fatalities and increase power reliability. Avian interactions (i.e. collisions and electrocutions) with overhead power lines, wind turbines, communication towers, and other utility structures can disrupt service and/or adversely affect bird populations. Current analyses estimate that birds cause approximately 10-25 percent of all U.S. outages. These outages can cost a utility \$500,000 annually in lost revenue, \$250,000 annually in repair, and \$250,000 to \$500,000 per incident in legal fines. Heightened awareness of the problem has spurred efforts to develop ways to avoid avian interactions with California's electrical infrastructure, thereby increasing power reliability throughout the state.

PIEREA and EPRI are developing and testing automated avian monitors to address the need to gather collision and electrocution information that is difficult and costly to obtain, to help standardize monitoring methods, and to evaluate the efficacy of bird deterrent devices. These monitors can be used in remote locations and could result in considerable cost savings by reducing time and personnel in the field.

This project consists of four separate tasks that are integrally related, although each task can stand alone and supply its own deliverable:

1. Beginning late in 2000, the research team developed a dead-bird search protocol. The protocol was based on existing protocols, and was modified for the particular field situation chosen for this study. Briefly, the field site is a 3.5-mile-long transmission and distribution corridor in North Dakota (> 20 wires per span) that separates an Audubon Wildlife Preserve

from a lake that is used daily by birds from the preserve.

Based on anecdotal information it was estimated that several hundred bird fatalities per year were occurring at this site.

2. The Bird Strike Indicator (BSI) is an impulse-based vibration sensing and recording tool to study bird collisions with aerial cables. The BSI would be placed directly on conductors (or guy wires on a communication tower) to detect strikes with wires and to distinguish bird strikes from other objects. The information, including impact, time, date, and conductor temperature would be transmitted to a ground station and retrievable via modem connection. This field-testing would occur simultaneously with on-the-ground searches to determine search bias.
3. The Bird Activity Monitor (BAM), which is an intelligent image-based sensing and recording tool to capture store, and transmit video images of bird incidents with utility structures (e.g., collision). The BAM could also be used to record bird flight activity around wind turbines and transmission lines, perching behavior on electricity poles, and bird responses to bird deterrent devices. To help ensure a successful outcome, a technical advisory group made up of project participants and potential stakeholders will review the technical performance objectives, designs, test plans, and results, and suggest improvements.
4. Line marking devices, sometimes know as Bird Flight Diverters (BFD), are readily available from a number of commercial sources. However, few, if any, have been scientifically evaluated to determine how well they work in the field. After the BSI and BAM have been completed and are available they will be used in the field to test the efficacy of existing and yet-to-be-designed BFDs at the site in North Dakota.

This project supports the PIER program objectives of:

- Improving the reliability/quality of California's electricity by increasing power reliability and reducing outages caused by avian interactions with utility structures. This can reduce energy operation and maintenance (O&M) costs and improve the value of California's electricity; and
- Improving environmental and public costs/risk from California's electricity system by developing devices to reduce avian fatalities from transmission and generation equipment. The monitors can also be used to test the efficacy of bird deterrent devices.

Proposed Outcomes:

- Protocol for on-the-ground searches for bird carcasses will be fine tuned for the specific site to provide the best estimates for comparison ultimately with data provided from automated devices.
- Determine areas with high collision risk. The development of

affordable and reliable devices to determine areas with high collision risk will enable power producers to implement mitigation at the most appropriate locations. This will allow California to transmission facilities, while minimizing adverse avian impacts. It will also reduce the cost of monitoring avian interactions to determine potentially problematic lines or poles.

- Reduce collisions and the incidence of temporary power outages. By employing these mitigation measures, power outages can be reduced and the reliability of the California electrical system can be increased. In addition, reducing maintenance and repair of costs will also reduce the cost of power production.
- Help stakeholders comply with applicable laws. The state and federal Endangered Species Acts, the Bald Eagle Protection Act, and the Migratory Bird Treaty Act all protect birds that can potentially be affected by utility structures. These monitoring tools will help power producers implement effective mitigation measures and comply with these laws.
- Better scientific data on utility effects on avian populations. Scientific evidence to determine how these bird interactions and fatalities affect avian populations is limited. Better data on the frequency of fatalities will provide insight into potential impacts on avian populations.

Project Status:

- Dead-bird searches have been conducted for two full field seasons, concluded in September 2002. These searches will not be conducted in 2003 in order that we may devote the maximum funding toward the hardware R&D effort. The data are being compiled, reduced, and evaluated, and will be discussed in a chapter in a forthcoming EPRI/CEC report titled *Bird Strike Indicator/Bird Activity Monitor and Field Assessments of Avian Mortality*.
- Design specifications for the bird strike indicator (BSI) were provided to EPRI by the contractor (EDM) in early 2002. Due to insufficient funding the hardware development lagged nearly five months. Since that time the components have been fabricated and bench tested. Limited field testing is being conducted by EDM during the winter of 2002-2003. During this period the components are being calibrated (for various bird strike intensities and cable dimensions) and evaluated for ruggedness and accuracy. A field demonstration is being scheduled for spring 2003.
- During 2002 the project developed the design specification for a bird activity monitor (BAM) and construction of a bench-scale prototype has begun. If continued funding is sufficient, field testing of the BAM will begin in fall of 2003 or spring 2004.
- Only small progress has been made on line marking devices. The initial field deployment and testing of these devices will

commence in 2004.

- In April 2003, EPRI will publish a CEC/EPRI progress report (1005385)

Measurement, Classification, and Quantification of Carbon Market Opportunities in the United States: California Component

Contract #: 100-98-001 **Project #:** 51

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$363,000

Contractor Project Manager: Kris Ebi (650) 855-2735

Commission Contract Manager: Kelly Birkinshaw (916) 654-4542

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to classify, quantify, and measure carbon market opportunities for land use change and forestry activities that could be implemented in the State of California. The resulting information will enable companies and organizations in California to make better decisions on how to participate in carbon markets that may emerge under future regulatory regimes.

The work has three major components:

1. Development of a baseline for the state that shows how carbon stocks in vegetation and soils have changed over the past decade;
2. Classification of the major opportunities for carbon storage on the land within the state and improved data on the quantity and costs of carbon storage for major classes of land-use and forest-based projects in California; and
3. Measurement services for carbon storage opportunities in California enabling accurate and precise estimation of the quantity of credits available from selected classes of projects.

This project complements, but is separate from, EPRI's Collaborative Carbon Initiative for measurement, classification, and quantification of carbon market opportunities in the United States. The EPRI initiative aims to improve the quality of information and analytical tools available to participants who wish to prepare for an uncertain future with respect to carbon dioxide limitations. This California specific component of the initiative will draw upon a wide range of public data.

This project supports the PIER Program objective of:

- Improving the environmental costs/risks of California's electricity by developing information and tools to support cost-effective approaches for carbon dioxide management.

Proposed Outcomes:

1. Perform measurement and design of monitoring activities to assess carbon credits from carbon storage projects in California. This will include developing a baseline of carbon emissions and/or sequestration in the land use and forestry sector of California for the period of 1990-2000, including identification and quantification of the magnitude of carbon sources and sinks. The project team will also perform measurement and design of carbon monitoring activities in California for one or more categories of potential carbon projects, including changes in forest management to increase large trees, fire management, reforestation of riparian ways, and conversion of grazing lands.
2. Develop a classification system for carbon storage opportunities in California, including a detailed analysis for one county. The project team will:
 - Prepare carbon supply curves for the major classes of potential land-use and forest-based activities in California in a format that allows comparison with opportunities in other regions.
 - Prepare detailed supply curves for carbon storage opportunities for one county using data available for individual parcels.
 - Prepare carbon supply curves for carbon storage opportunities within the agricultural sector that may not be significant at the state level but could be important at the county or regional level.
3. Expand a database being developed under the Collaborative Carbon Initiative to allow for a preparation of carbon supply curves for biomass energy and estimation of carbon credits that would result from decreased energy use associated with urban forestry projects.

Project Status:

During 2002, work focused on the development of the state baseline and data collection and analysis of the major carbon storage opportunities. Measurement and monitoring work will begin in 2003 pending identification of priority projects for measurement.

For the baseline, Winrock has collected and evaluated available geographic data against a variety of criteria: resolution, extent, collection date, future availability and cost. Winrock is working closely with the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program to identify the advantages and disadvantages of various datasets. Preliminary comparisons of the various data sources have been done for Yolo and Sacramento counties to illustrate how the choice of datasets will affect results.

Classification and quantification of carbon storage opportunities began with collection and organization of appropriate economic data and development of habitat suitability maps derived from

the Natural Resource Conservation Service's STATSGO databases to identify areas best suited for specific activities (grains, woodlands, rangelands, etc.). Economic data and land suitability maps will be combined with other data to produce supply curves for carbon credits in 2003.



Target 43 Water Quality Criteria and Toxics in Aquatic Environments

Contract #: 100-98-001

Contractor: EPRI

Subcontractors: Great Lakes Environmental Center; University of Wisconsin; University of Trent; Tetra Tech; Fresh Water Institute; Water Environment Research Foundation; EA Engineering Science and Technology; United States Geological Survey; Allegheny Power; Frontier Geosciences; Battelle Northwest Laboratories; ICF Consultants

Contract Amount: 2000: \$120,000

Match Funding: 2000: \$1,541,861

Contractor Project Manager: John Goodrich-Mahoney, (650) 855-5256

Commission Project Manager: Joe O'Hagen, (916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to provide the CEC with information and tools to help improve the scientific basis for California water quality criteria. The products of this target may also facilitate the use of site-specific conditions and new data to assess 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 inform ongoing deliberations and to increase understanding of critical issues.

This project supports the PIER Program objective of:

- Improving the environmental and public health costs/risks of California's electricity by providing tools that lead to more precise estimates of human health and ecological risks and establish the basis for more cost-effective regulations and compliance methods.

Proposed Outcomes:

1. Upgrade the Dynamic Mercury Cycling Model, which models mercury deposition, transformation, and bioaccumulation in lakes.
2. Develop models for assessing metal toxicity on a site-specific basis.
3. Develop a guidance document for determining a site-specific criterion for selenium.
4. Evaluate and improve risk assessment methodologies for water quality criteria.
5. Provide information on the health risks of arsenic.
6. Improve the accuracy of criteria for contaminated sediments.
7. Assess the emerging field of biocriteria and its application to water bodies.
8. Explore the application of persistent bioaccumulative toxics (PBTs) to metals and inorganic metal compounds.

Actual Outcomes:

An upgraded version of the Dynamic Mercury Cycling Model - *Dynamic Mercury Cycling Model Version 1.1* (1001114) – was produced. The model will be helpful in assessing total maximum daily load of mercury in several large California lakes.

1. A biotic ligand model (BLM) for copper was developed. This model can be used to develop site-specific metal toxicity in California water bodies.
2. A technical workshop was held to develop a guidance document for determining a site-specific criterion for selenium.
3. Risk assessment methodologies.
 - A report was published evaluating of current Federal risk-assessment methodologies.
 - A user's guide to RIVRISK, Version 5.0, - *User's Guide for RIVRISK Version 5.0: A Model to Assess Potential Human Health and Ecological Risks from Power Plant and Industrial Facility Releases to Rivers* (1000733) - was published. This model can be used to assess human health and ecological risks associated with industrial and power plant chemical and thermal releases to rivers.
 - EPRI prepared technical comments on EPA's proposed rule on human health methodology.
4. A peer-reviewed white paper was published summarizing EPRI research conducted over several years on the health risks of arsenic. EPRI also prepared technical comments on the EPA proposed rule on arsenic.
5. Contaminated sediments.
 - A report - *Overview and Evaluation of the U.S. Environmental Protection Agency's Sediment Quality and Sediment Criteria Program* (1000437) - was published providing a critical assessment and review of EPA activities and research on contaminated sediments.
 - Proceedings were published of an EPRI workshop on sediment guidance and regulation.
6. Proceedings - *Proceedings of the 1999 Workshop on Biocriteria: Framework and Implementation* (1000435) - were published of an EPRI-hosted national workshop on biocriteria.
7. A workshop - *Experts Workshop: Review of the State-of-the-Science Regarding PBT Concepts and Metals and Metal Compounds* (WM-114920) - was held to explore the state-of-the-science concerning application of PBTs to metals and inorganic metal compounds, principally mercury and lead.

Status:

This project is complete.

Targets 87.0 Hydropower Operations, Relicensing and Environmental Issues;

87.1 Environmental Issues Management

Contract #: 100-98-001

Contractor: EPRI

Subcontractors: B.C. Hydro International Ltd.; HCI Publications; Iris Power Engineering Inc; Kearns & West Inc; EA Engineering; Science & Technology Inc; Lang, Railsback & Associates; Lockheed Martin Energy Research Corp.

Contract Amount: 1999: \$71,400

2000: \$28,800

Match Funding: 1999: \$826,738

2000: \$564,554

Contractor Project Manager: Norris Hirota, (650) 855-2084

Commission Project Manager: Linda Spiegel, (916) 654-5061

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to address the challenges facing the hydroelectric industry that come in the areas of Federal Energy Regulatory Commission (FERC) relicensing and environmental mitigation. Balancing the protection of fish and wildlife resources with multiple demands for water use can be optimized by utilizing credible scientific information, tools, and methods. The management of hydro project decommissioning, including impoundment sediment management (characterization, removal, and disposal), dam removal, and ecosystem restoration are complex technical issues for which little background science exists. This EPRI tiered target offers cost-effective solutions to address critical relicensing, environmental, and public issues related to the hydro industry, by utilizing the world-renowned expertise of EPRI scientists and engineers, forums for sharing information and capitalizing on the lessons learned by others, and leveraged development of solutions to common problems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by compiling expert knowledge on the best practices for optimizing hydro plant operations and performance to enhance grid reliability;
- Improving the energy cost/value of California's electricity by helping to minimize the cost of hydropower while protecting the environment; and
- Improving the environmental costs/risks of California's electricity by providing expert knowledge on addressing multi-stakeholder relicensing issues and by studying how best to manage entire watersheds containing hydroelectric development, rather than managing hydro projects individually.

Proposed Outcomes:

1. Improve the relicensing process to achieve results acceptable to all stakeholders at minimum cost to stakeholders by providing information on relicensing best practices for the hydropower industry.
2. Provide information on of worldwide technological developments relevant to the hydropower business
3. Improve fish protection methods by providing scientific information, techniques, and guidance based on state-of-the-art and emerging methods for instream flow management.
4. Provide assessment methods for more accurately evaluating the effects of turbine entrainment and mortality on fish populations.
5. Provide information and tools for determining cost-effective upstream and downstream fish passage and protection needs for migratory and nonmigratory fish.
6. Provide information for water resources management to optimize power production while complying with environmental protection requirements.
7. Offer a cost-effective approach for site-specific environmental data gathering and ecosystem research needs while providing future communication links with the environmental management, regulatory, and research community.

Actual Outcomes:

1. Best practices.
 - A *Preferred Practices Guidebook* was developed that outlines effective hydro relicensing practices.
 - The National Relicensing Group (NRG), sponsored by EPRI, developed a manual on best practices for hydropower relicensing entitled *Hydro Relicensing Forum: Relicensing Strategies* (1000737).
 - The NRG met three times in 2000 to discuss issues related to relicensing and to develop the best practices manual.
2. New information was provided in several reports for optimizing hydropower operations through rehabilitation, upgrading, condition monitoring, and life extension of hydropower facilities. They are *Hydro Life Extension Modernization Guide: Volume 1: Overall Process* (TR-112350-V1), *Hydro Life Extension Modernization Guides: Volume 2: Hydromechanical Equipment* (TR-112350-V2), *Steel Penstock Coating and Lining Rehabilitation: A Hydropower Technology Roundup Report, Volume 3* (TR-113584-V3), and *Hydro Life Extension Modernization Guide: Volume 7 - Protection and Control* (TR-112350-V7).
3. Instream flow management.
 - EPRI's Individual-Based Instream Trout Model was developed and successfully tested.
 - A review and evaluation of state-of-the-art instream flow assessment methods was conducted, compiled in a draft report, peer-reviewed, and published in a final report.

4. Assessment methods for turbine entrainment and mortality
 - An improved modeling approach was developed for studying fish behavior and impacts of hydro systems on fish.
5. Fish passage and protection needs.
 - An evaluation was made of bar racks and louvers for preventing turbine entrainment and guiding fish to bypasses. Tests were conducted on lake sturgeon, shiners, walleye, smallmouth bass, and American eels, and results published in a report.
 - Two symposia were held and papers published on passage and protection of catadromous eels and green sturgeon.
6. New information was presented on the extent and severity of reservoir sedimentation problems in the United States and current practices to mitigate or prevent sediment-related problems, including a case study at a California hydroelectric project.
7. Support was provided for graduate research fellowships in Ecology and Hydrology.

Status:

This project is complete.

Target 103/44 Fish Protection Issues (Clean Water Act, Sections 316 a&b)

Contract #: 100-98-001

Contractor: EPRI

Subcontractors: Alden Research Laboratory Inc; Applied Biomathematics Inc; Duke Energy Corporation; EA Engineering, Science & Technology; Langhei Ecology LLC; Lockheed Martin Energy Systems Inc; Tennessee Valley Authority; Tetra Tech Inc; Kenneth Rose

Contract Amount: 1999: \$262,700

2000: \$262,700

Match Funding: 1999: \$2,838,013

Match Funding: 2000: \$2,858,821

Contractor Project Manager: Doug Dixon, (804) 642-1025

Commission Project Manager: Linda Spiegel, (916) 653-5061

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to provide methods for studying fish entrainment and impingement mortality and generate results for fish population predictions that will be used to address biological community and biodiversity risks associated with power plant and industrial facilities operations. The protection of single fish species and aquatic communities is a primary focus of water permitting for coal, oil, gas, and nuclear power plants and industrial facilities under Clean Water Act Section 316(a) (heated and chlorinated cooling water discharges), and Section 316(b) (entrainment into

intakes and impingement on intake screens). This EPRI target will support cost-effective fish protection and facility operational decision-making.

This project supports the PIER Program objectives of:

- Improving the environment costs/risks of California's electricity by studying how to reduce the negative effects of thermal power plants (using once-through cooling) on aquatic resources in freshwater and marine environments; and
- Improving the public health costs/risks of California's electricity by protecting fish in cost effective ways to minimize environmental impacts on aquatic environments that impact humans.

Proposed Outcomes:

1. Provide California with effective "best technology available" (BTA) engineering methods for cooling system intakes.
2. Provide objective science and engineering to the California energy enterprise debate in water use impacts.
3. Develop accurate ecological risk assessment tools to assess the effects of power plant operation on individual fish and the risks to aquatic communities for cost-effective fish protection options.
4. Develop Aquatic Ecosystem Evaluation Methods, Ecological Risk Assessment Frameworks, Compensation Mechanisms in Fish Populations (CompMech), and Thermal Discharge Risk Analyses.

Actual Outcomes:

1. Intake fish protection system assessments.
 - A report was produced summarizing a review of fish protection technologies at cooling water intakes.
 - Research was conducted and a report produced on the effectiveness of bar racks and louvers for preventing passage of fish through turbines at hydroelectric projects.
 - Guidelines were published for selecting technologies appropriate for "best technology available" (BTA) analysis based on site-specific factors such as plant design, representative fish species present, and others. The guidelines will help California facilities determine their own best BTA options prior to construction.
2. Objective science and engineering on water use impacts.
 - Proceedings were published of a technical workshop on the Clean Water Act Section 316(b).
 - A report was published on methods for evaluating nursery and spawning habits.
3. Ecological risk assessment methods.
 - New information was developed on ecological risk endpoints for abundant species. This project will provide a method for resource agencies to benchmark the risk of

any impact on various species.

- An ecological risk case study was conducted on Hudson River striped bass, applying the ecological risk endpoints method.
 - A report was published on performing a human health and ecological risk assessment using the RIVRISK software program.
 - A report was published on using water approach velocity as a screening tool.
 - A report was published on adapting risk analysis processes to 316(b) Tier 3 Assessments.
 - A database was compiled on entrainment survival for fish and other aquatic species.
4. Aquatic ecosystem evaluation methods.
- A catalog was published on assessment methods for evaluating the effects of power plant operations on aquatic communities.
 - A report was published on applying biocriteria as a concept, approach, and tool for assessing impacts of entrainment and impingement under 316(b).

Status:

This project is complete.

Target 105/46 Facilities Water Management

Contract #: 100-98-001 **Project #:** 16

Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Di Filippo Michael, Lytle Mel C, Alabama Power Company, BetzDearborn, Inc., Gannett Fleming, Inc., Puckorius & Associates Inc., University of California, Berkeley, University of Iowa, University of Southern California, Water Systems Specialists Inc

Project amount: \$110,400

Match amount: \$1,674,490

Contractor Project Manager: Kent Zammit (650) 855-2097

Commission Contract Manager: Joe O'Hagan
(916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to develop and implement cost-effective strategies for controlling biofouling, treating wastewater, and treating and recycling cooling water while maintaining minimal impact on the environment. This EPRI target will focus on strategies that include reducing biocide discharges, removing heavy metals, minimizing nitrogen compounds to reduce eutrophication (an aquatic environment wherein plant life is favored over animal life) of water resources, and reducing bioaccumulative pollutants from plant wastewater. For example, EPRI has demonstrated the use of constructed wetlands for treatment of point- and non-point source aqueous discharges.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing cost-effective alternative water sources and alternative technologies/methods of treatment of these alternative water sources; and
- Improving the environmental and public health costs/risks of California's electricity by providing solutions that reduce or eliminate the water-related impacts of electricity generation in California.

Proposed Outcomes:

1. Provide biofouling control and plant performance strategies.
2. Provide cost-effective wastewater treatment strategies.
3. Provide cooling water treatment and reuse strategies.
4. Conduct a Tailored Collaboration entitled "Degraded Water Study" to assess the use of degraded water sources within California in lieu of potable sources for closed-loop cooling of new power generation projects.
5. Conduct a Tailored Collaboration entitled "Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Technologies" for evaluation of the opportunities to implement lower water use options for power plant cooling in California.

Actual Outcomes:

1. Biofouling control.
 - A preliminary report was published on evaluation of non-toxic biofouling technologies.
 - A report was published on follow-up bench-scale tests and power plant slipstream evaluation of non-toxic biofouling technologies.
 - The 10th International Zebra Mussel Conference was cosponsored by EPRI.
 - Research was conducted on controlling the biofouling of heat exchangers and cooling systems using new chemical and nonchemical macrofouling control technologies—in preparation for publication in 2001 of the *Revised Guidelines for Macrofouling Control Technology*.
2. Wastewater treatment.
 - A report - *Improvement of Plants for Selenium and Heavy Metal Phytoremediation Through Genetic Engineering* (TR-114219) - was published on the successful use of genetically engineered plants with superior capabilities for the phytoremediation of heavy metals such as selenium, molybdenum, cadmium, and tungsten.
 - The use of iron-coated sand was demonstrated for reducing solid waste volumes by orders of magnitude relative to iron co-precipitation, the current industry standard.
 - An assessment report, field test report, and guidelines were published for treating water using plant impounds in

which toxic substances precipitate in holding ponds.

- A report - *The San Francisco Bay Constructed Wetland Treatment System: The Use of Constructed Wetland Treatment Systems for the Removal of Toxic Trace Elements from Electric Utility Wastewater: Role of Vegetation* (1000269) - was published on research conducted at the Chevron constructed wetland treatment system on San Francisco Bay on the role of wetland plants in the volatilization of selenium and other toxic trace elements.
 - Research was conducted on wastewater treatment for removal of nitrogen compounds—in preparation for possible publication in 2001 of the *Guidelines for Wastewater Treatment for Removal of Nitrogen Compounds*.
3. Cooling water treatment and reuse.
- Results were published on the first pilot study of alternative biocide compounds for control of microfouling and macrofouling in cooling towers.
 - Case studies were conducted on the recycling and reuse of power plant water and wastewater to help reduce the cost and environmental consequences of water purchase, use, and discharge—in preparation of publication in 2001 of new guidelines.
4. A report on the use of degraded water for power plant cooling was delivered in 2002. See separate write-up in this annual report under the title "Degraded or Reclaimed Power Plant Cooling Water".
5. A report evaluating the costs, design impacts, effects on generation capacity, and R&D needs for applying wet, dry, hybrid wet/dry, and alternative cooling systems for power generation applications in California was delivered in 2002. See separate write-up in this annual report under the title "Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Strategies".

Status:

The Commission's participation in this target ended December 31, 2000. The tailored collaboratives are complete.

Water Quality Criteria and Toxics in Aquatic Environments

Contract #: 100-98-001 **Project #:** 24

Contractor: Electric Power Research Institute (EPRI)

Subcontractors: Great Lakes Environmental Center, University of Wisconsin, University of Trent, Tetra Tech, Fresh Water Institute, Water Environment Research Foundation, EA Engineering Science and Technology, United States Geological Survey Allegheny Power, Frontier Geosciences, Battelle Northwest Laboratories, ICF Consultants

Project amount: \$120,000

Match amount: \$1,541,861

Contractor Project Manager: John Goodrich-Mahoney
(650) 855-5256

Commission Contract Manager: Joe O'Hagan
(916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project was to provide the CEC with information and tools to help improve the scientific basis for California water quality criteria. The products of this target may also facilitate the use of site-specific conditions and new data to assess 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 inform ongoing deliberations and to increase understanding of critical issues.

This project supports the PIER Program objective of:

- Improving the environmental and public health costs/risks of California's electricity by providing tools that lead to more precise estimates of human health and ecological risks and establish the basis for more cost-effective regulations and compliance methods.

Proposed Outcomes:

1. Upgrade the Dynamic Mercury Cycling Model, which models mercury deposition, transformation, and bioaccumulation in lakes.
2. Develop models for assessing metal toxicity on a site-specific basis.
3. Develop a guidance document for determining a site-specific criterion for selenium.
4. Evaluate and improve risk assessment methodologies for water quality criteria.
5. Provide information on the health risks of arsenic.
6. Improve the accuracy of criteria for contaminated sediments.
7. Assess the emerging field of biocriteria and its application to water bodies.
8. Explore the application of persistent bioaccumulative toxics (PBTs) to metals and inorganic metal compounds.

Actual Outcomes:

An upgraded version of the *Dynamic Mercury Cycling Model - Dynamic Mercury Cycling Model Version 1.1* (1001114) – was produced. The model will be helpful in assessing total maximum daily load of mercury in several large California lakes.

1. A biotic ligand model (BLM) for copper was developed. This model can be used to develop site-specific metal toxicity in California water bodies.

2. A technical workshop was held to develop a guidance document for determining a site-specific criterion for selenium.
3. Risk assessment methodologies.
 - A report was published evaluating of current Federal risk-assessment methodologies.
 - A user's guide to RIVRISK, Version 5.0, - *User's Guide for RIVRISK Version 5.0: A Model to Assess Potential Human Health and Ecological Risks from Power Plant and Industrial Facility Releases to Rivers* (1000733) - was published. This model can be used to assess human health and ecological risks associated with industrial and power plant chemical and thermal releases to rivers.
 - EPRI prepared technical comments on EPA's proposed rule on human health methodology.
4. A peer-reviewed white paper was published summarizing EPRI research conducted over several years on the health risks of arsenic. EPRI also prepared technical comments on the EPA proposed rule on arsenic.
5. Contaminated sediments.
 - A report - *Overview and Evaluation of the U.S. Environmental Protection Agency's Sediment Quality and Sediment Criteria Program* (1000437) - was published providing a critical assessment and review of EPA activities and research on contaminated sediments.
 - Proceedings were published of an EPRI workshop on sediment guidance and regulation.
6. Proceedings - *Proceedings of the 1999 Workshop on Biocriteria: Framework and Implementation* (1000435) - were published of an EPRI-hosted national workshop on biocriteria.
7. A workshop - *Experts Workshop: Review of the State-of-the-Science Regarding PBT Concepts and Metals and Metal Compounds* (WM-114920) - was held to explore the state-of-the-science concerning application of PBTs to metals and inorganic metal compounds, principally mercury and lead.

Status:

This project is complete.

Sediment Issues at California Hydroelectric Facilities

Contract #: 100-98-001 **Project #:** 46

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$37,500

Match amount: \$37,500

Contractor Project Manager: Doug Dixon (804) 642-1025

Commission Contract Manager: Kelly Birkinshaw
(916) 654-4542

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to evaluate sedimentation problems at California's hydropower facilities. A 1995–96 survey by the Federal Energy Regulatory Commission (FERC) indicated that approximately one in four reservoirs in the United States had sedimentation problems, including environmental degradation, contaminated sediments, and operational loss. Sediment loading threatens environmental resources and the continued viability of hydroelectric generation. To ensure environmentally sound and productive hydropower generation in California, researchers need to identify the nature and extent of sedimentation problems at California's hydropower facilities.

In this project, PIEREA and EPRI are examining sediment issues (e.g., loading, contamination, gravel trapping, potential fish and aquatic impacts, and removal options) at hydropower facilities in California. The team is characterizing sedimentation issues—including the nature and extent of problems and remedial actions undertaken or planned—at all FERC-licensed and federal California hydropower operations via an electronic questionnaire and follow-up phone interviews. Researchers will also review and summarize environmentally responsible remedial strategies and develop a framework for sediment management guidelines for California hydroelectric and other water resource operations.

The project will establish a database on the nature and extent of sedimentation problems at California hydroelectric facilities, and will publish a report characterizing sedimentation issues at California hydroelectric facilities.

This project supports the PIER Program objectives of:

- Providing environmentally sound electricity by providing the information necessary to implement environmentally responsible mitigation measures through characterizing the sedimentation at California's dams; and
- Ensuring reliable energy services by developing remedial measures to reduce sedimentation that will lead to greater generation capacity at California's hydro facilities.

Proposed Outcomes:

- Increased output from hydroelectric dams. Mitigation strategies that will enable hydropower operators to remove sediments with less risk to aquatic organisms will help operators increase electricity production. The information will be particularly useful California's hydroelectric facilities that must renew their licenses by 2010.
- Decreased environmental impacts from contaminated sediments. This information will provide California's water resource managers with information to plan appropriate actions to prevent or mitigate sediment-related problems.

Actual Outcomes:

In 2001 PIEREA and EPRI examined and characterized sediment issues at hydropower facilities in California, reviewed environmentally responsible remedial strategies, developed a framework for sediment management guidelines, and prepared a final report describing project findings. The draft final report from this effort was delivered to the Commission for review in early 2002. Because of the low response rate to the survey, the Commission decided not to finalize the report.

Project Status:

EPRI is currently investigating the feasibility of increasing the response rate via an informal phone survey of California hydroelectric operators. This phone survey is being conducted via EPRI base funds. The Commission's involvement has ended for the time being.

Target 53 Water Quality Criteria and Toxics In Aquatic Environments

Contract #: 500-00-023 **Project #:** 19

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$103,525

Match amount: \$1,604,494

Contractor Project Manager: John Goodrich-Mahoney
(202) 293-7516

Commission Contract Manager: Joe O'Hagan (916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to provide the Energy Commission with information and tools to help improve the scientific basis for California water quality criteria. The products of this target may also facilitate the use of site-specific conditions and new data to assess 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 inform ongoing deliberations, and to increase understanding of critical issues.

This project supports the PIER Program objective of:

- Improving the environmental and public health costs/risks of California's electricity by providing tools that lead to more precise estimates of human health and ecological risks and establish the basis for more cost-effective regulations and compliance methods.

Proposed Outcomes:

1. Apply the Mercury Cycling Model—which predicts ecosystem responses to changing mercury loadings—in field tests to improve its representation of mercury cycling through lakes and streams.

2. Support research to develop a scientifically sound approach to site-specific permitting of selenium discharges to streams and rivers.
3. Develop a technical report on the biological criteria development process to reduce regulatory uncertainty and associated costs.
4. Conduct a Tailored Collaboration entitled "Sedimentation Issues at Hydroelectric Facilities."

Actual Outcomes:

1. A technical report, "*Controls on Fluxes of Mercury in Aquatic Food Webs: Application of the Dynamic Mercury Cycling Model to Four Enclosure Experiments with Additions of Stable Mercury Isotopes*," (1005171) was published. The report describes a pilot study that demonstrated the efficacy of using stable mercury isotopes in large-scale, in situ, process-level experiments investigating mercury cycling in natural ecosystems. Results of the pilot study were critical to the design of a full-scale experiment designed to address the question of what happens to fish mercury concentrations when there is a change in atmospheric mercury deposition.
2. A workshop on selenium dynamics in running waters enabled researchers, EPA, and stakeholders to review results from prior research activities and fine tune the research program for the next year. Workshop proceedings were published in 2002.
3. A technical report, "*Selenium Cycling and Impact in Aquatic Ecosystems: Defining Trophic Transfer and Water-Borne Exposure Pathways*," (1005217) was published. The report concludes that selenite-exposed algae produce higher levels of Selenium in zooplankton than do algae exposed to equivalent concentrations of selenate.
4. A technical report describing field evaluations of the biological criteria development process was published in 2002.

Project Status:

This project is complete.

Target 54 Fish Protection Issues of the Clean Water Act Section 316(a) and (b)

Contract #: 500-00-023 **Project #:** 20

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$236,395

Match amount: \$2,797,326

Contractor Project Manager: Kent Zammit (650) 855-2097

Commission Contract Manager: Joe O'Hagan (916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to support cost-effective fish protection and facility operational decision-making. The protection of single fish species and aquatic communities is a primary focus of water permitting for coal, oil, gas, and nuclear power plants and industrial facilities under Clean Water Act Section 316(a) (heated and chlorinated cooling water discharges), and Section 316(b) (entrainment into intakes and impingement on intake screens). This project provides methods for studying fish entrainment and impingement mortality and generating results for fish population predictions that will be used to address biological community and biodiversity risks associated with power plants and industrial facilities.

This project supports the PIER Program objectives of:

- Improving the environmental costs/risks of California's electricity by studying how to reduce the negative effects of thermal power plants (using once-through cooling) on aquatic resources in freshwater and marine environments; and
- Improving the public health costs/risks of California's electricity by protecting fish in cost-effective ways to minimize environmental impacts on aquatic environments that impact humans.

Proposed Outcomes:

1. Produce a fish protection synthesis report that integrates all the information collected and developed in response to this issue for the purpose of regulatory development and implementation of those regulations.
2. Sponsor workshops and national conferences to explore technical issues related to Section 316(a) and (b) regulatory developments.
3. Provide guidance for the selection and application of aquatic ecosystem evaluation methods. Of particular importance is the utility of bioassessment criteria as screening tools for determining the potential for adverse environmental impacts for once-through cooling water operations.
4. Develop risk assessment tools applicable to Section 316(a) and (b) demonstrations, and endangered and threatened species issues.
5. Support research on technologies for protecting fish at water intakes.

Actual Outcomes:

1. 316(b) Fish Protection Synthesis Report
 - A technical report – *Spawning and Nursery Habitat Assessment Methods* (1000732) – was published. This report covers methods available for identifying and assessing the quality of aquatic spawning and nursery habitat, and other sensitive areas, of relevance to cooling

water intake systems (CWIS).

- An Internet resource was developed to provide current information on fish protection issues.
 - A quarterly technical newsletter (March, June, September and December) was published summarizing peer-reviewed technical publications of relevance to power plant impacts on fish populations.
2. Workshops/Conferences on Water Use Impacts on Aquatic Resources
 - A customer workshop on ongoing projects was held in January 2001, providing detailed information on the progress of ongoing research and discussion of potential revision and new research needs.
 - A workshop for EPRI customers, EPA, and invited technical experts was held in January 2001 to share information on the EPA regulatory framework.
 - A symposium on Defining and Assessing Adverse *Environmental Impact under Section 316(b) of the Clean Water Act* was held in conjunction with the American Fisheries Society Annual Meeting, August 2001. Papers from this symposium were peer-reviewed and published both in electronic format and in a printed book.
 3. Aquatic Ecosystem Evaluation Methods
 - A report – *Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact under Clean Water Act Section 316(b)* (1000731) – was published, providing an evaluation of EPA's proposal to use velocity as criteria for determining the potential for population impacts by assessing velocity into cooling water intake systems.
 4. Ecological Risk Assessment Frameworks
 - A report – *Evaluating the Effects of Power Plants on Aquatic Communities: Guidelines for Selection of Assessment Methods* (1005176) – was published. The report provides guidelines for selecting methods to estimate effects of cooling water withdrawals on aquatic populations and communities.
 - A technical literature paper – *Compensatory Density Dependence in Fish Populations: Importance, Controversy, Understanding and Prognosis* – by Ken Rose and five other authors was published in the December 2001 issue of *Fish and Fisheries* (Volume 2, pages 293-327). This paper provides a comprehensive review on the state-of-knowledge relative to compensation or density-dependence theory.
 - A technical workshop was held November 15-16, 2001 at the decommissioned Connecticut Yankee plant to review a previous Connecticut River ecological study. The workshop examined the long-term impacts of the plant and the current status of fish populations in the river.

5. Intake Technology Research

- EPRI initiated a project with collaborative water quality grant funding from the U.S. EPA that is investigating the efficacy of cylindrical wedge wire screens for fish protection at water intakes. Research will be concluded in December 2002.
- A book — *Behavioral Technologies for Fish Protection at Water Intakes* (1006198) — was published by the American Fisheries Society with 100% EPRI support. The book contains 15 technical papers that review various behavioral technologies (e.g., light, sound, flow patterns) that may be used to guide fish away from water intakes.

Project status:

This project is complete.

Target 55 TMDL, Watershed and Ecosystem Issues

Contract #: 500-00-023

Contractor: EPRI

Subcontractors: Systech Engineering Inc.; Tetra Tech Inc.; University of California, Santa Barbara; Humboldt State University; Freshwater Institute (Canadian Dept. of Fisheries and Oceans); University of Maryland; Resources Strategies Inc.

Contract Amount: 2001: \$135,300

Match Funding: 2001: \$1,959,583

Contractor Project Manager: Robert Goldstein, (650) 855-2593

Commission Project Manager: Joe O'Hagan, (916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: This program delivers scientific information, guidance, and tools to support cost-efficient, risk-based strategies for integrated watershed management and ecosystem protection.

Momentum is building for a more integrated framework for environmental management and protection. Environmental regulations and initiatives are being developed whose scope goes beyond the protection of individual waterways and species to focus on entire watersheds and ecosystems. Controls are also under consideration for nonpoint sources of pollution such as air emissions from industry and transportation. The integrated watershed/ecosystem management approach encompasses emerging issues such as coastal water eutrophication, effluent trading, and analysis and allocation of total maximum daily load (TMDL—the maximum influx of contaminants a water body can receive without damage). This program delivers knowledge and tools for calculating TMDLs, analyzing allocation strategies, assessing the ecological effects of nonpoint sources of pollution, and implementing effluent trading strategies.

This project supports the PIER program objectives of:

- Improving the environmental costs/risks of California's electricity by providing information and tools that enable companies, regulators, and stakeholders to assess cumulative impacts and risks on a facility-specific and watershed-wide basis, analyze the costs and benefits of management alternatives, and implement cost-efficient management strategies; and
- Improving the public health costs/risks of California's electricity by providing integrated strategies to minimize environmental impacts on watersheds and ecosystems that may affect humans.

Proposed Outcomes:

1. Provide and support an analytic framework (the EPRI Watershed Analysis Risk Management Framework, WARMF) to support the watershed approach and TMDL calculations. WARMF is a decision support system for assessing integrated effects and evaluating alternative management strategies for the diverse array of pollutant sources (point and nonpoint) within a watershed. It also provides a structured approach for building consensus among stakeholders.
2. Provide methods and data to assess the influence of atmospheric deposition and other nonpoint source pollution on the ecological health of watersheds, estuaries, wetlands, and lakes.
3. Develop information and methods supporting the application of market-based strategies for ecological resource management and effluent trading.

Actual Outcomes:

1. Watershed Analysis Risk Management Framework
 - A report — *Watershed Analysis Risk Management Framework (WARMF): Update One: A Decision Support System for Watershed Analysis and Total Maximum Daily Load Calculation, Allocation, and Implementation* (1005181) — was published. The report documents and illustrates the application of EPRI's WARMF decision support software to conduct TMDL analyses and allocate TMDLs among stakeholders.
 - A report — *Peer Review of the Acid Mine Drainage Module of the Watershed Analysis Risk Management Framework (WARMF): An Evaluation of WARMF/AMD Using EPA Guidelines* (1005182) — was published. The report contains results of an EPA-requested peer review, using EPA guidelines and independent experts., of WARMF's Acid Mine Drainage Module for use in developing TMDLs for watersheds where acid mine drainage is an important issue.
 - A WARMF training workshop was conducted to teach stakeholders, regulators, and students the underlying

principles of TMDLs and watershed analysis and to train them in the use of the WARMF decision support system.

2. Watershed Assessment of Atmospheric Deposition
 - A software product, *the Estuary Eutrophication Framework: General Version* (1001415), was developed. The software provides a user-friendly tool to estimate phosphorus and nitrogen loads to estuaries from land-based and atmospheric sources and to predict the impact of these nutrients on dissolved oxygen levels.
 - A workshop, *Nitrogen Stable Isotope Tracer Research Design*, was conducted to examine the state of the science and develop an experimental design to quantify the fates of atmospherically deposited nitrogen compounds.
3. Ecological Resource Management and Effluent Trading
 - A report – *Water Quality Trading Guidance Manual: An Overview of Program Design Issues and Options* (1005179) – was published. The manual provides guidance on establishing new effluent trading programs, including identifying and resolving issues that could affect their development and use. The manual includes an overview of existing trading programs, information about completed trades, and a review of federal and state effluent trading regulations and policies.

Project status:

This project is complete.

Target 56 Facilities Water Management

Contract #: 500-00-023 **Project #:** 22

Contractor: Electric Power Research Institute (EPRI)

Subcontractors: Dr. John S. Maulbetsch; University of Southern California; Waters Edge Technology, LLC; Karl Wilber; Mike DiFilippo; Dr. Detlev Kroger, University of Stellenbosch; Dr. Ishwar Murarka, Ish-Inc.

Project amount: \$62,196

Match amount: \$677,718

Contractor Project Manager: Rick Carlton (650) 855-2115

Commission Contract Manager: Joe O'Hagan (916) 653-1651

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to develop and implement cost-effective strategies for controlling biofouling, treating wastewater, and treating and recycling cooling water while maintaining minimal impact on the environment. This EPRI target will focus on strategies that include reducing biocide discharges, removing heavy metals, minimizing nitrogen compounds to reduce eutrophication (an aquatic environment wherein plant life is favored over animal life) of water resources, and reducing bioaccumulative

pollutants from plant wastewater. For example, EPRI has demonstrated the use of constructed wetlands for treatment of point- and non-point source aqueous discharges.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing cost-effective alternative water sources and alternative technologies/methods of treatment of these alternative water sources. The purposes of these alternatives are to minimize environmental impact at reduced costs for treatment of cooling water and increased water recycling/reuse, while improving plant performance and preventing corrosion damage; and
- Improving the environmental and public health costs/risks of California's electricity by providing solutions that reduce or eliminate the water-related impacts of electricity generation in California.

Proposed Outcomes:

1. Provide biofouling control and plant performance strategies.
2. Provide information and methods for designing constructed wetlands as a low-cost alternative for meeting water quality standards.
3. Conduct a Tailored Collaboration entitled "Degraded or Reclaimed Power Plant Cooling Water."
4. Conduct a Tailored Collaboration entitled "Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Technologies."

Actual Outcomes:

1. Biofouling Control
 - The 11th International Zebra Mussel Conference was cosponsored by EPRI.
 - A biofouling control conference was cosponsored by EPRI.
2. Constructed Wetlands
 - A report—*Phytoremediation of Trace Elements by Wetland Plants* (1005185)—was published. The report describes research to quantify the capacity of various wetland plant species to remove trace elements from polluted water.
3. Tailored Collaboration – Degraded or Reclaimed Power Plant Cooling Water
 - The final report on the results of this work was delivered in 2002.
4. Tailored Collaboration – Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Technologies.
 - Research was conducted to evaluate the tradeoffs between alternative cooling technologies. Findings are presented in a report that was peer-reviewed and delivered in 2002.

Project status:

This project is complete.

Target 57 Rights-of-Way Environmental Issues in Siting, Development, and Management: Avian Interactions With Utility Structures, Wind Turbines, and Communication Towers Tailored Solution Package

Contract #: 500-00-023 **Project #:** 23

Contractor: Electric Power Research Institute (EPRI)

Subcontractors: EPRI Solutions, Resource Strategies Inc., URS Greiner Woodward Clyde, EDM International Inc. : Western EcoSystems Technology Inc.

Project amount: \$31,690

Match amount: \$699,825

Contractor Project Manager: John Goodrich-Mahoney
(650) 855-5256

Commission Contract Manager: Joe O'Hagan
(916) 653-1651

Project Description: This program's tools and information support rights-of-way (ROW) practices that protect the environment while controlling costs associated with ROW siting, development, and management. Environmental issues confronting ROW owners and users include avian interactions (bird collisions, nesting and perching) with power and communications structures environmental impacts of access roads, biodiversity and habitat fragmentation.

Concurrently, ROW siting, development, and management are increasingly guided by government policies and regulations. Competitive markets demand reliable, high-quality electrical service while compelling companies to be ever mindful of capital and operational budgets. Dealing with these challenges requires balancing cost-effectiveness with compliance, environmental stewardship, and responsiveness to the public. This program develops and delivers scientific information and innovative approaches to help ROW owners/users contain costs while responding to the competitive marketplace and practicing environmental stewardship.

This project supports the PIER program objectives of:

- Improving the environmental costs/risks of California's electricity by providing information and methods that enable companies, regulators, and stakeholders to assess, minimize, and mitigate environmental impacts associated with rights of way and to implement cost-effective ROW management strategies; and
- Improving the reliability/quality of California's electricity by providing information and tools for cost-effective vegetation management practices for identifying and controlling vegetation that poses a risk to the transmission system.

Proposed Outcomes:

1. Provide information and methods to address rights-of-way

- environmental and land-use issues to enhance the ROW environment and to avoid or mitigate environmental impacts.
2. Develop information on reducing negative interactions between birds and transmission/distribution structures, wind turbines, and communications towers.
3. Provide information and tools to support cost-effective and environmentally sound ROW vegetation management practices.
4. Develop information for cost-effective identification of danger trees and other ROW-bordering vegetation posing a risk to the transmission system.
5. Evaluate the impacts of access road construction at stream crossings and through wetlands.
6. Provide a detailed plan for integrating public communications into ROW projects.

Actual Outcomes:

1. Rights-of-Way Environmental and Land Use Issues
 - A software product – *The Rights-of-Way Bibliographic Database, Version 1.0* (1005190) – was developed and released. The software provides a convenient information resource to support cost-effective and environmentally sound ROW management practices.
2. Avian Interactions
 - A report – *Avian Interactions with Utility and Communication Structures: Proceedings of a Workshop Held in Charleston, South Carolina, December 2-3, 1999* (1005180) – was published with support by the Avian Power Line Interaction Committee of the Edison Electric Institute. The report includes manuscripts or abstracts of the workshop's 24 presentations, which addressed a wide range of subjects including interactions between bats and utility structures, cooperative approaches to solving avian interaction problems, and legal aspects of avian interactions with manmade facilities.
3. Vegetation Management
 - A report – *Vascular Species Richness and Rarity in Wetlands on Electric Power Rights of Way in New York State* (1005187) – was published. The report examines the impact of ROW construction and management on plant diversity and vascular species richness.
 - A report – *Rights of Way Mechanical Cutting and Disposal Costs—Update 2001* (1005186) – was published. The report updates earlier research to determine the factors influencing ROW cutting and disposal costs.
 - EPRI cosponsored the Seventh International Symposium on Environmental Concerns in Rights-of-Way Management. Papers presented at the conferences were submitted for publication.
4. Danger Tree Assessment
 - A report – *Airborne Inspection System (AIS) Version 2.0*

Product Specifications (1005191) – was published. The report details the proposed functions and features of the AIS, a software tool that offers an efficient way to use digital aerial patrol data—including high-resolution imagery, digital video, and GPA coordinates—for cost-effective identification of vegetation posing a risk to the transmission system.

5. Impacts of Road Construction

- Research was conducted to evaluate regulatory issues (including a critical evaluation of all mandated best practices), cost implications, and environmental concerns related to development of access roads in the vicinity of water bodies. Results are presented in a report – *Best Practices Manual for Access Road Crossings of Wetlands and Waterbodies* (1005188) - published in March 2002.

6. Public Communications

- A report – *Communicating with the Public About Rights of Way: A Practitioner's Guide* (1005189) – was published. The report describes a systematic eight-step template for planning ROW public communications to improve the public dialog concerning ROW issues.

Project status:

This project is complete.

Target 58 Environmental Issues Management

Contract #: 500-00-023 **Project #:** 24

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$46,125

Match amount: \$779,219

Contractor Project Manager: Doug Dixon (804) 642-1025

Commission Contract Manager: Linda Spiegel
(916) 654-4703

Commission Contract Manager: Gary Klei, (916) 653-8555

Project Description: The purpose of this project is to provide practical information, guidance and tools 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. These products help hydropower operators effectively balance environmental protection and water resource demands with power generation.

For all hydropower operators, typical environmental issues include fish passage, in-stream flow restoration and protection, turbine entrainment and mortality, and water quality protection. Other issues relate to flood protection and water resource allocation for recreation, drinking water, and irrigation. Sediment management and proper decommissioning issues represent new challenges. This EPRI target offers cost-effective

solutions to address critical hydro relicensing, environmental, and public interest issues through scientific and engineering expertise, forums for sharing information and lessons learned, and leveraged development of solutions to common problems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by compiling expert knowledge on the best practices for optimizing hydro plant operations and performance to enhance grid reliability;
- Improving the energy cost/value of California's electricity by helping to minimize the cost of hydropower while protecting the environment; and
- Improving the environmental costs/risks of California's electricity by providing expert knowledge on addressing multi-stakeholder relicensing issues and by studying how best to manage entire watersheds containing hydroelectric development, rather than managing hydro projects individually.

Proposed Outcomes:

1. Provide information and tools for determining cost-effective passage and protection needs for migratory and nonmigratory fish. EPRI provides a forum for exploring existing and emerging migratory and nonmigratory fish issues, evaluating passage and protection technologies, and identifying research needs. Researchers are evaluating designs for more effective downstream passage facilities and approaches that mitigate turbine entrainment and spillway-related mortality.
2. Improve the ability to assess cumulative impacts and manage water resources for optimized power production while complying with environmental protection requirements.
3. Provide information and tools that improve project decommissioning and sediment management while addressing ecosystem protection and restoration concerns.

Actual Outcomes:

1. Fish Passage and Protection Management
 - A report – *Evaluation of Angled Bar Racks and Lowers for Guiding Fish at Water Intakes* (1005193) – was published. The report presents information to support the evaluation of this fish protection technology for potential application at specific projects. The report also demonstrates how computational fluid dynamic modeling (CFD) can be used as a new tool to examine the local hydraulic performance of physical structures and how knowledge of local hydraulic conditions may affect fish avoidance response.
 - Proceedings were published from EPRI symposia on catadromous eels and sturgeon conducted in association

with the American Fisheries Society at the AFS Annual Meeting in 2000. The peer-reviewed proceedings serve as a published record of papers presented at the symposia and were published in book form by the AFS.

- A book – *Behavioral Technologies for Fish Protection at Water Intakes* (1006198) – was published by the American Fisheries Society with 100% EPRI support. The book contains 15 technical papers that review various behavioral technologies (e.g., light, sound, flow patterns) that may be used to guide fish away from water intakes.
- Collaborative research with the U.S. Department of Energy, Hydropower Program and American Electric Power (AEP) was initiated to evaluate the effectiveness of artificial flow fields for guiding downstream migrating fish in hydroelectric forebays to bypasses (precluding turbine entrainment and mortality).

2. Water Resource Management

- An EPRI report – *Maintaining and Monitoring Dissolved Oxygen at Hydroelectric Projects* (1005194) – was published. This report provides a review of technologies and techniques for enhancing dissolved oxygen (DO) levels in reservoirs and releases from hydroelectric projects. The report also covers methods, equipment and techniques for monitoring DO levels.

3. Project Decommissioning and Sediment Management

- A report on the Heinz Center Study – *Dam Removal Decisions: Science and Decision Making* – was published by the Heinz Center. The report provides a framework and information sources for supporting project decommissioning and dam removal decisions. The current focus is on small, low-head, run-of-river dams. EPRI is supporting this collaborative effort of the Heinz Center, U.S. Bureau of Reclamation, and Federal Emergency Management Administration. A panel of experts from the funding organizations, academia, and non-governmental environmental organizations prepared the report.

Project status:

This project is complete.

Program 53 Mercury, Metals and Organics in Aquatic Environments

Contract #: 500-00-023 **Project #:** 54

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$103,525

Match amount: \$1,134,111

Contractor Project Manager: John Goodrich-Mahoney
(202) 293-7516

Commission Contract Manager: Kelly Birkinshaw
(916) 654-4542

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to provide the CEC with information and tools to help improve the scientific basis for California water quality criteria. The products of this program may also facilitate the use of site-specific conditions and new data to assess 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 inform ongoing deliberations and to increase understanding of critical issues.

This project supports the PIER Program objective of:

- Improving the environmental and public health costs/risks of California's electricity by providing tools that lead to more precise estimates of human health and ecological risks and establish the basis for more cost-effective regulations and compliance methods.

Proposed Outcomes:

1. Enhance the Dynamic Mercury Cycling Model—which predicts ecosystem responses to changing mercury loadings—and conduct field research into processes that affect mercury fluxes and bioavailability in aquatic ecosystems.
2. Conduct research to support improvements to the process by which EPA establishes national ambient aquatic life criteria and the development of models for assessing metal toxicity on a site-specific basis.
3. Apply new and updated information on arsenic health effects to address specific issues related to reducing uncertainties in the cancer health risk assessment for arsenic in water, and reduce reliance on conservative default assumptions in human health risk estimates for arsenic.
4. Provide an assessment of the biological criteria development process as it may affect industry along large rivers.

Actual Outcomes:

1. Dynamic Mercury Cycling Model
 - EPRI developed and released Version 2.0 of the Dynamic Mercury Cycling Model. Version 2 allows estimation of mercury speciation, pool sizes, fluxes, transformations and fish tissue concentrations. This enhanced software enables users to analyze "what if" scenarios based on changing environmental conditions or mercury loading rates.
 - A peer-reviewed paper, *Differences in Reactivity and Mobility Between New and Old Mercury Deposition in a Boreal Ecosystem*, was submitted to *Environmental Science and Technology*.
2. Aquatic Life Criteria

- A technical report, *Characterizing the Risk Associated With Episodic Exposure of Metals in Effluents: Influence of Episodic Copper Exposure on Daphnia magna* (1005319), was published. The report describes EPRI research on fluctuating exposures in aquatic systems and the prediction of acute and chronic lethal effects. Results of this research were also presented at the recent Society of Environmental Toxicology and Chemistry annual meeting in Salt Lake City.
- A peer-reviewed paper, *Population Response of Daphnia magna to Copper Exposure Over Multiple Generations*, (E207963) was submitted to *Environmental Toxicology and Chemistry* in January for publication.

3. Health Risks from Arsenic

- Researchers integrated existing and recent data on arsenic's biological mode of action and toxicokinetics, focusing on the pharmacokinetic model for arsenic. Results were presented at the Fifth International Conference on Arsenic Exposure and Health Effects. EPRI cosponsored the conference, which was held in San Diego in July 2002. Research results will also be delivered as peer literature, "Advancement Toward a Biologically Realistic Cancer Risk Assessment for Inorganic Arsenic," (E207964), which will be published in the conference proceedings.

4. Biological Criteria Assessment

- A technical report, *Fish Sampling in Large Freshwater Rivers: A Review of the Methods* (1005322) was published. The document reviews guidance from a total of 29 reports regarding fish sampling protocols for large freshwater rivers. It also discusses how biocriteria might be applicable to the assessment of fish communities in large rivers and includes recommendations on future research.

Project Status:

This project is complete.

Program 54 Section 316(a) and (b) Fish Protection Issues

Contract #: 500-00-023 **Project #:** 55

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$236,395

Match amount: \$3,109,764

Contractor Project Manager: Kent Zammit (650) 855-2097

Commission Contract Manager: Kelly Birkinshaw (916) 654-4542

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to support cost-effective fish protection and facility operational decision-making. The protection of single fish species and

aquatic communities is a primary focus of water permitting for coal, oil, gas, and nuclear power plants and industrial facilities under Clean Water Act Section 316(a) (heated and chlorinated cooling water discharges), and Section 316(b) (entrainment into intakes and impingement on intake screens). This project provides methods for studying fish entrainment and impingement mortality and generating results for fish population predictions that will be used to address biological community and biodiversity risks associated with power plants and industrial facilities. The project also evaluates the effectiveness of cooling water intake fish protection technologies such as cylindrical wedge wire screens, bar racks/louvers, and aquatic filter barriers.

This project supports the PIER Program objectives of:

- Improving the environmental costs/risks of California's electricity by studying how to reduce the negative effects of thermal power plants (using once-through cooling) on aquatic resources in freshwater and marine environments; and
- Improving the public health costs/risks of California's electricity by protecting fish in cost-effective ways to minimize environmental impacts on aquatic environments that impact humans.

Proposed Outcomes:

1. Produce a fish protection synthesis report that integrates all the information collected and developed in response to this issue for the purpose of regulatory development and implementation of those regulations.
2. Sponsor workshops and national conferences to explore technical issues related to Section 316(a) and (b) regulatory developments.
3. Provide guidance for the selection and application of aquatic ecosystem evaluation methods. Of particular importance is the utility of bioassessment criteria as screening tools for determining the potential for adverse environmental impacts for once-through cooling water operations.
4. Provide an assessment of compliance options for fish protection through the use of an intake structure database to inform science-based, cost-effective regulatory decision-making.
5. Develop risk assessment framework information applicable to Section 316(a) and (b) demonstrations, and endangered and threatened species issues.
6. Evaluate and enhance cost-effective current and emerging technologies for protecting fish at cooling water intake structures.
7. Provide guidance for monitoring of entrainment and impingement mortality, and selection of appropriate BTA (best technology available) technologies for evaluation.

8. Provide guidance on suitable cost-benefit analysis for BTA determinations.

Actual Outcomes:

1. 316(b) Fish Protection Synthesis Report
 - An interim technical report, *Enhancement Strategies for Mitigating Potential Operational Impacts of Cooling Water Intake Structures: Approaches for Enhancing Environmental Resources* (1005326), was published. The report describes environmental enhancement or restoration approaches that may be applicable for mitigating impingement and entrainment impacts associated with cooling water intake structures (CWISs).
 - A final report, *Enhancement Strategies for Mitigating Potential Operational Impacts of Cooling Water Intake Structures: Approaches for Enhancing Environmental Resources* (1007454) was published at the end of 2002.
2. Workshops/Conferences on Water Use Impacts on Aquatic Resources
 - A symposium on *Defining and Assessing Adverse Environmental Impact under Section 316(b) of the Clean Water Act* was held in conjunction with the American Fisheries Society Annual Meeting, August 2001. Papers from this symposium were submitted to a publisher, were peer-reviewed and published both in electronic format and in a printed book.
3. Aquatic Ecosystem Evaluation Methods
 - EPRI reviewed the impacts of CWIS operation for each major water body type and published results in a report — *Technical Summary of Environmental Impacts from CWIS Operation* (1005178).
4. Intake Structure Database
 - A technical update document was prepared that provides an informal progress report on development of the Entrainment and Impingement Database. This database has been further developed this year in support of projects to evaluate entrainment and impingement mortality.
5. Ecological Risk Assessment Frameworks
 - A report—*Evaluating the Effects of Power Plant Operations on Aquatic Communities: An Ecological Risk Assessment Framework for Clean Water Act Section 316(b) Determinations* (1005176) was published in July 2002. The report describes a general framework for ecological risk assessment proposed by the U. S. Environmental Protection Agency and explains how this framework can be integrated into the decision-making process under Section 316(b). This report complements EPRI reports TR-112013 and 1005176. These three reports provide technically sound guidance for assessing the potential for adverse environmental impact resulting from

cooling water withdrawals and evaluating the potential ecological benefits of mitigation alternatives.

- A report, *Connecticut River Ecological Study Workshop: Revisiting the Impact of a Power Plant: November 15-16, 2001*, The University of Connecticut Marine Sciences Institute at Avery Point (1006900) was published. The report summarizes a technical workshop held November 15-16, 2001 at the decommissioned Connecticut Yankee plant to review a previous Connecticut River ecological study. The workshop examined the long-term impacts of the plant and the current status of fish populations in the river.
6. Intake Fish Protection
 - In research cofunded with EPA, EPRI investigated the efficacy of cylindrical wedge wire screens for protecting fish at water intakes. Research began in 2001 and concluded in December 2002. Preliminary results were presented in August at the annual meeting of the American Fisheries Society. A technical report, *Evaluation of Cylindrical Wedge-Wire Screens* (1005339) was drafted and submitted for publication in December 2002.
 - EPRI began flume tests to characterize performance and physical properties of a new entrainment technology, the aquatic filter barrier.

Project status:

The project is complete.

Program 55 TMDL, Watershed, and Ecosystem

Contract #: 500-00-023 **Project #:** 56

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$135,300

Match amount: \$1,454,682

Contractor Project Manager: Robert Goldstein
(650) 855-2593

Commission Contract Manager: Kelly Birkinshaw
(916) 654-4542

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: This program delivers scientific information, guidance, and tools to support cost-efficient, risk-based strategies for integrated watershed management and ecosystem protection. Momentum is building for a more integrated framework for environmental management and protection. Environmental regulations and initiatives are being developed whose scope goes beyond the protection of individual waterways and species to focus on entire watersheds and ecosystems. Controls are also under consideration for nonpoint sources of pollution such as air emissions from industry and transportation.

The integrated watershed/ecosystem management approach encompasses emerging issues such as mercury and nitrogen atmospheric deposition, coastal water eutrophication, water quality trading, water resource sustainability under growing demand for water use, and analysis and allocation of total maximum daily load (TMDL—the maximum influx of contaminants a water body can receive without damage). This program delivers knowledge and tools for calculating TMDLs, analyzing allocation strategies, assessing the ecological effects of nonpoint sources of pollution, and implementing water quality trading strategies.

This project supports the PIER program objectives of:

- Improving the environmental costs/risks of California's electricity by providing information and tools that enable companies, regulators, and stakeholders to assess cumulative impacts and risks on a facility-specific and watershed-wide basis, analyze the costs and benefits of management alternatives, and implement cost-efficient management strategies; and
- Improving the public health costs/risks of California's electricity by providing integrated strategies to minimize environmental impacts on watersheds and ecosystems that may affect humans.

Proposed Outcomes:

1. Provide an analytic framework (the EPRI Watershed Analysis Risk Management Framework: WARMF) to support the watershed approach and TMDL calculations. WARMF is a decision support system for assessing integrated effects and evaluating alternative management strategies for the diverse array of pollutant sources (point and nonpoint) within a watershed. It also provides a structured approach for building consensus among stakeholders.
2. Provide methods and data to assess the influence of atmospheric deposition and other nonpoint source pollution on the ecological health of watersheds, estuaries, wetlands, and lakes.
3. Develop information and methods to support the application of market-based strategies for sustainable ecological resource management and water quality trading.

Actual Outcomes:

1. TMDL/Watershed Analysis
 - EPRI published report – *A Review of Total Maximum Daily Load (TMDL) Program: An Assessment of States' Implementation of Section 303(d) of the Clean Water Act* (1005343) in October 2002. The report reviews accessible TMDL reports, summarizes the EPA's TMDL program, outlines potential impacts of TMDLs on the electric power industry, and identifies research and other action needed

to strengthen the TMDL program. This report will be valuable to industry, agriculture, and environmental and government organizations involved in management and protection of watershed resources and compliance with water quality criteria.

- EPRI published a report – *TMDL Consensus Simulation Workshop Using WARMF Framework* (1005498) – that presents results of a workshop to test the consensus-building module of EPRI's Watershed Analysis Risk Management Framework (WARMF). The workshop focused on WARMF as a decision-support tool. In particular, it focused on the use of the Consensus Module to provide information needed to define various stakeholder positions and communicate information needed to understand the watershed and its response to various management alternatives. The workshop's objective was to have real stakeholders evaluate the Consensus Module within the context of a simulated, realistic application. Workshop results will prove valuable to industry, agriculture, environmental groups, and government agencies involved in managing and protecting watershed resources and complying with water quality criteria.
- EPRI published report – *Comparison of BASINS and WARMF Models: Mica Creek Watershed* (1005344). The report documents fundamental differences in how the two watershed models are conceptualized, calibrated, and applied. This information will be useful to stakeholders including industrial, agricultural, environmental, and governmental organizations concerned with TMDLs.
- EPRI published a four-volume EPRI Report on Water & Sustainability
 - Volume 1: *Research Plan* (1006784)
 - Volume 2: *An Assessment of Water Demand, Supply and Quality in the U.S. – The Next Half Century* (1006785)
 - Volume 3: *U.S. Water Consumption for Power Production – The Next Half Century* (1006786)
 - Volume 4: *U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century* (1006787).
- The following peer-reviewed papers were produced:
 - Herr, J., C. Chen, R. A. Goldstein, R. Herd, and J.M. Brown. "Modeling Acid Mine Drainage on a Watershed Scale For TMDL Calculations," *Journal of American Water Resources Association*, (in press).
 - Herr, J, C. Chen, R.A. Goldstein, and J.N. Brogdon. "A Tool for Sediment TMDL Development on Oostanaula Creek, In Total Maximum Daily Load (TMDL) Environmental Regulations," *Proceedings of March 11-13, 2002 Conference, Society for Engineering in Agriculture, Food, and Biological Systems*, ASAE Publication 701P0102, pp. 111-116 (2002).

2. Watershed Assessment of Atmospheric Deposition and other Nonpoint Source Pollution

- In 2002 the project team enhanced EPRI's Estuary Eutrophication Framework to address the cycling and effects of atmospheric deposition of mercury in addition to nitrogen and phosphorous. A technical report presenting the results is scheduled for publication in March 2003.
- A group of expert scientists identified research needs and developed an experimental design to quantify the fate of atmospherically deposited nitrogen compounds. Results will be presented in an informal technical progress report, *Nitrogen Stable Isotope Tracer Research Design* (1005349).
- EPRI-funded research produced the following peer reviewed publications:
 - Inputs and Outputs of Mercury from Terrestrial Watersheds: A Review*. D.F. Grigal. *Environmental Reviews*, 10, pp. 1-39 (2002).
 - Babiarz, C.L., J.P. Hurley, D.P. Krabbenhoft, C. Gilmour, and B. Branfireun. "Application of Ultrafiltration and Stable Isotopic Amendments to Field Studies of Mercury Partitioning to Filterable Carbon in Lake Water and Overland Runoff." In J. Munthe (ed.), Proc. 6th International Conference on Mercury as a Global Pollutant. Minimata, Japan, Oct 15-19, 2001. Published in *Science of the Total Environment*. This publication was produced by the METAALICUS project that is cofunded by Program 55.
 - "Mercury Sequestration in Forests and Peatlands: A Review," D.F. Grigal. *Journal of Environmental Quality* (in press).

3. Sustainable Ecological Resource Management and Effluent Trading

- EPRI published a technical report – *Water Quality Trading Guidance Manual* (1005179) that provides water quality trading program developers with an overview of issues they will need to address and summarizes relevant lessons from existing water quality trading programs.
- EPRI developed a technical report – *Modeling Methods for Water Quality Trading* (1005350) – that will describe the use of models to support the development and implementation of effluent trading programs. It will be available in the first quarter of 2003.

Ongoing Research and Activities:

The following research and activities that took place in 2002 will produce publications in later years:

- WARMF case studies in North Carolina, South Carolina, Tennessee, Nebraska, Minnesota, Wisconsin, and Colorado. The Colorado study is funded by a USEPA grant. The others

are funded by tailored collaboration (TC).

- Development of eco-indices to support water quality trading. TC funded.
- Study of feasibility of water quality trading. TC funded.
- Study of major environmental issues for different industry sectors in a common watershed. TC funded.
- Development of methods using stable isotopes to identify pollutant sources.
- Participation in the Federal Advisory Committee on Water Information and the Sustainable Water Resources Round Table.
- Member support.

Project status:

The project is complete.

Program 57 Rights-of-Way Environmental Issues in Siting, Development and Management

Contract #: 500-00-023 **Project #:** 58

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$49,200

Match amount: \$641,459

Contractor Project Manager: John Goodrich-Mahoney (202) 293-7516

Commission Contract Manager: Kelly Birkinshaw (916) 654-4542

Commission Contract Manager: Gary Klein, (916) 653-8555

Project Description: This program's tools and information support rights-of-way (ROW) practices that protect the environment while controlling costs associated with ROW siting, development, and management. Environmental issues confronting ROW owners and users include avian interactions (bird collisions, nesting and perching) with power and communications structures, environmental impacts of access roads, biodiversity and habitat fragmentation.

Concurrently, ROW siting, development, and management are increasingly guided by government policies and regulations. Competitive markets demand reliable, high-quality electrical service while compelling companies to be ever mindful of capital and operational budgets. Dealing with these challenges requires balancing cost-effectiveness with compliance, environmental stewardship, and responsiveness to the public. This program develops and delivers scientific information and innovative approaches to help ROW owners/users contain costs while responding to the competitive marketplace and practicing environmental stewardship.

This project supports the PIER program objectives of:

- Improving the environmental costs/risks of California's electricity by providing information and methods that enable companies, regulators, and stakeholders to assess, minimize, and mitigate environmental impacts associated with rights of way and to implement cost-effective ROW management strategies; and
- Improving the reliability/quality of California's electricity by providing information and tools for cost-effective vegetation management practices for identifying and controlling vegetation that poses a risk to the transmission system.

Proposed Outcomes:

1. Provide information and tools to support cost-effective and environmentally sound ROW management practices.
2. Develop tools for cost-effective identification of danger trees and other ROW-bordering vegetation posing a risk to the transmission system.
3. Develop new approaches for reducing negative interactions between birds and transmission/distribution structures, wind turbines, and communications towers.

Actual Outcomes:

1. Information and Tools for Environmentally Sound, Cost-effective ROW Management
 - EPRI produced a technical update document, *Wildlife and Integrated Vegetation Management on Electric Transmission Line Rights-of-Way* (1005366), that describes integrated vegetation management (IVM) methods and discusses the role of IVM in maintaining biodiversity as well as ecosystem integrity and function.
 - EPRI published a report, *Best Management Practices (BMPs) Manual for Access Road Crossings of Wetlands and Waterbodies* (1005188), in March 2002. The manual addresses the selection and use of best management practices for the construction and/or maintenance of wetland and waterbody crossings by access roads associated with electric utility lines. Although the focus of this manual is on electric utility access roads, the contents are likely to be applicable to a much broader range of linear projects, including other types of roads and projects. The publication received the 2002 "Outstanding Environmental Resource Document" award from the San Diego chapter of the Association of Environmental Professionals.
 - In 2002 EPRI published the proceedings from the Seventh International ROW Symposium, which brought together worldwide experts who shared and debated new ideas for managing ROWs. The publication, *Environmental Concerns in Rights-of-Way Management: Seventh International Symposium: 9 - 13 September 2000*,

Calgary, Alberta, Canada (1006500), presents 101 peer-reviewed papers on current environmental issues involved in rights-of-way management.

2. Danger Tree Assessment

- A new version of Airborne Inspection System (AIS) software (1005376) was developed to support evaluation of vegetation conditions from digitized data collected using airborne imaging technology. This will allow quick location and assessment of danger trees in a cost-effective manner during ROW construction and maintenance.

3. Avian Interactions

- A workshop on Avian Interactions with Wind Power Structures was held October 16-17, 2002, and drew more than 130 attendees from the United States and abroad.
- A technical update – the proceedings from the above workshop, which will have the same title (1005384) – will be available in April 2003. The document will provide guidance for assessing, preventing, and reducing bird and bat mortality at windpower facilities.
- A technical report – *Bird Strike Indicator/Bird Activity Monitor and Field Assessments of Avian Mortality* (1005385) – which is in preparation, describes case studies and provides new information on ways to avoid and/or mitigate avian interactions with power structures.
- A master's thesis titled "Assessment of Bat Community Structure and Roosting Habitat Preferences for the Hoary Bat (*Lasiurus cinereus*) Near Foote Creek Rim, Wyoming," was successfully defended in September 2002 at the Department of Zoology and Physiology of the University of Wyoming by candidate Jeffrey C. Gruver. This thesis will be published as an EPRI report in 2003. The document provides previously unknown information on bat ecology that is relevant to wind power development.

Project status:

This project is complete.

Program 58 Hydropower Relicensing Environmental Issues

Contract #: 500-00-023 **Project #:** 59

Contractor: Electric Power Research Institute (EPRI)

Subcontractors: Lang, Railsback & Associates, Alden Research Laboratory, Heinz Center, Versar Inc., Oak Ridge National Laboratory

Project amount: \$46,125

Match amount: \$449,928

Contractor Project Manager: Doug Dixon (804) 642-1025

Commission Contract Manager: Linda Spiegel (916) 654-4703

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: This program provides practical information, guidance and tools 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. These products help hydropower operators effectively balance environmental protection and water resource demands with power generation.

For all hydropower operators, typical environmental issues include fish passage, in-stream flow restoration and protection, turbine entrainment and mortality, and water quality protection. Other issues relate to flood protection and water resource allocation for recreation, drinking water, and irrigation. Sediment management and proper decommissioning issues represent new challenges. This EPRI target offers cost-effective solutions to address critical hydro relicensing, environmental, and public interest issues through scientific and engineering expertise, forums for sharing information and lessons learned, and leveraged development of solutions to common problems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by compiling expert knowledge on the best practices for optimizing hydro plant operations and performance to enhance grid reliability;
- Improving the energy cost/value of California's electricity by helping to minimize the cost of hydropower while protecting the environment; and
- Improving the environmental costs/risks of California's electricity by providing expert knowledge on addressing multi-stakeholder relicensing issues and by studying how best to manage entire watersheds containing hydroelectric development, rather than managing hydro projects individually.

Proposed Outcomes:

1. Develop a methodology for determining instream flow needs via a professional judgment (qualitative) approach.
2. Provide information and tools for determining cost-effective passage and protection needs for migratory and nonmigratory fish.
3. Improve the ability to assess cumulative impacts and manage water resources for optimized power production while complying with environmental protection requirements.
4. Provide information and tools that improve project decommissioning and sediment management while addressing ecosystem protection and restoration concerns.
5. Complete a Tailored Collaboration entitled "Sedimentation Issues at California Hydro Facilities."

Actual Outcomes:

1. Instream Flow Management
 - Technical efforts are progressing on developing the qualitative instream flow prediction approach. A final report will be available by December 31, 2003.
2. Fish Passage and Protection Management
 - In 2002 EPRI began development of a desk reference on technologies and approaches for upstream and downstream fish passage. The Fish Passage Manual will be developed in a loose-leaf binder format to facilitate future insertion of revised chapters as the state of the art in fish passage technology advances. Initial 2002 efforts focused on development of the manual framework, a literature review, and collection of other information on fish passage. Progress on the manual is summarized in an informal technical update report, *Upstream and Downstream Fish Passage and Protection Technologies for Hydroelectric Application: A Fish Passage and Protection Manual* (1005392). Efforts in 2003 will focus on completing the manual.
 - Researchers examined the influence of fluid dynamics on fish behavior, including role of (1) riverine turbulence in the migratory paths selected by downstream-migrating fish, and (2) fluid flows near and in turbines that result in fish injury and mortality. Researchers also examined how computational fluid dynamic (CFD) modeling can simulate the functional attributes of fluid flows important to fish movements and damage. Research results may lead to improvements in active and passive technologies for guiding organisms toward bypasses or away from hazards such as spillways and turbine intakes. A technical update report presenting the results – *Application of Eco-Hydraulic Principles to Fish Passage/Protection* (1005391) – was prepared and submitted for publication. Research on this issue will continue into 2003.
3. Water Resource Management
 - An EPRI report – *Maintaining and Monitoring Dissolved Oxygen at Hydroelectric Projects: Status Report* (1005194) – was published in May 2002. The report provides hydropower operators with state-of-the-art information on methods and technologies for mitigating dissolved oxygen (DO) issues in hydro project reservoirs and tailwaters.
4. Sediment and Project Decommissioning Management
 - A report on the Heinz Center Study – *Dam Removal Decisions: Science and Decision Making* – was published by the Heinz Center in May 2002. The report provides a framework and information sources for supporting project decommissioning and dam removal decisions. The current focus is on small, low-head, run-of-river dams. EPRI supported this collaborative effort of the Heinz Center, U.S. Bureau of Reclamation, and Federal Emergency

Management Administration. A panel of experts from the funding organizations, academia, and non-governmental environmental organizations prepared the report. Copies of this report (1005396) can be obtained from the EPRI Distribution Center

5. Tailored Collaboration – Sedimentation Issues at California Hydro Facilities

- PIEREA and EPRI examined and characterized sediment issues at hydropower facilities in California, reviewed environmentally responsible remedial strategies, developed a framework for sediment management guidelines, and prepared a final report describing project findings. The draft final report from this effort was delivered to CEC for review in early 2002. Because of the low response rate to the EPRI survey, CEC decided not to finalize the report. EPRI is currently investigating the feasibility of increasing the response rate via an informal phone survey of California hydroelectric operators. This phone survey is being conducted via EPRI base funds.

Project status:

This project is complete.



Projects Funded through the Energy Systems Integration PIER Program Area

- Projects Funded in 2002
- Projects In Progress
- Projects Completed



Seismic Studies

Contract #: 500-01-025 **Project #:** 1

Contractor: Electricity Innovation Institute

Project amount: \$22,400

Match amount: \$20,000

Contractor Project Manager: Ben Damsky
(650) 855-2385

Commission Contract Manager: David Chambers
(916) 653-7067

Project Description: The purpose of this project is to seismically qualify substation equipment in accordance with the new IEEE Standard 693, IEEE Recommended Practice for Seismic Design of Substations. Non-seismically qualified substation equipment is a primary cause of damage and disruptions from earthquakes in California.

This project is needed to reduce costs by combining resources to qualify the equipment, and to have equipment that is pre-qualified so that facility construction is not delayed due to qualification. It will also qualify equipment that has the most vulnerable configuration so that other equipment variations can be qualified by similarity methods. A consortium of utilities will provide guidance to the project. Testing will be performed at appropriate test facilities as directed by the consortium.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by qualifying substation equipment to meet the IEEE Standard 693; and
- Improving the safety of California's electricity by providing utilities access to equipment that has been qualified in accordance with the standard.

Proposed Outcomes:

1. Develop improved seismic procedures for conducting shake-table tests on selected equipment.
2. Verify compliance of selected substation equipment with IEEE Standard 693.
3. Understand deficiencies of the standard for the qualification of transformer bushings and propose improvements.

Actual Outcomes:

1. Selected test facility, prioritized order of tests, established equipment support structure specifications, defined vibration test requirements, and determined specifications for electrical equipment and tests.
2. Tested and qualified eight CVTs from two manufacturers, including a 230-kV porcelain unit, a 500-kV porcelain unit, three types of 230-kV composite units, and three types of 500-kV composite units.

3. Established the groundwork for testing and qualifying disconnect switches. This includes developing a support structure for the 230-kV switches, identifying switch manufacturers willing to participate, and developing an RFP to go to manufacturers.
4. Two models of transformer bushings have been developed that indicate that a more detailed model is needed.

Project Status:

Commission staff are participating in the project. A follow-on two-year project, starting in 2003, is planned.

High Temperature, Low Sag Conductor

Contract #: 500-01-025 **Project #:** 2

Contractor: Electricity Innovation Institute

Project amount: \$212,000

Contractor Project Manager: Raymond Lings
(650) 855-2177

Commission Contract Manager: Jamie Patterson
(916) 657-4819

Project Description: The purpose of this project is to evaluate the performance of selected "high-temperature, low-sag" conductors that are capable of significantly increasing the ampacity of thermally constrained transmission lines without the need for extensive tower redesign. Examples include 3M, CRAC, and Gapped conductors, and commercial forms of aluminum steel-supported conductors (ACSS) such as ACSS-TW.

The majority of overhead transmission lines currently use steel-reinforced aluminum conductors (ACSRs). ACSRs can be routinely operated at temperatures up to 100 degrees Celsius (212° F) and, during emergencies, at temperatures as high as 150 degrees Celsius (302° F). Today, however, power industry deregulation is placing new demands on the delivery system and altering high-voltage transmission network power flow patterns. Consequently, networks are increasingly being forced to support power flows for which they were never designed.

One approach to addressing this dilemma would involve upgrading the transfer capacity through reconductoring of selected network lines. In recent years, conductor manufacturers have produced new, nontraditional conductors capable of operating at temperatures as high as 250 degrees Celsius (482° F) without violating present electrical clearances to ground and other objects. While these conductors have passed accepted industry standards tests for performance, utilities are wary of installing these yet unproven technologies without having first gained an insight into their performance in a real-world setting.

The project will provide participating utilities with information on the operational performance of these new conductors through approximately three years of field trial experience and funder-specified laboratory tests. In addition, the project will evaluate the performance of conductor fittings -- including splices and dead-ends -- in both field and laboratory tests.

Further, the project will compile practical "engineering-type" information to aid utilities in designing, specifying, installing, inspecting, and maintaining the conductors. The results will position participating utilities as informed buyers and users of the technology.

The project will answer questions, such as:

- How do manufacturer claims compare to field and laboratory performance?
- What are the design parameters for these conductors?
- What engineering changes are necessary when replacing existing conductors with these products?
- What is the impact of these conductors on existing tower design?
- What special handling precautions apply?
- How do these conductors age, and what factors influence aging?
- What is the long-term performance of line hardware?
- How do conductor fittings perform under high temperature over long periods?
- What are the costs of operation and lifetime costs?
- What inspection techniques should be used?
- What engineering guidelines and training materials are required?

Participants in this project will be able to take advantage of the project review meetings, held twice a year, plus the monthly and quarterly updates. At the project review meetings, progress will be reported and revisions to the plan discussed. The progress of the following deliverables can be updated:

- Field and laboratory test results. Progress reports will be generated after every sampling period.
- Technical workshops. Workshops will be conducted on specific engineering and technical aspects. Examples may include visits to manufacturers, site visits, observation of fieldwork, and training for designers and field personnel.
- Final project report and workshops. The final report will include a summary and analysis of the field and laboratory results. Results will be presented to funders at the final project workshop.
- Participants will have the benefit of gaining first-hand experience on installation and operation of "high-

temperature, low-sag" transmission conductors. Host utilities will have the "high-temperature, low-sag" transmission conductor installed in their transmission system, benefiting from its higher thermal rating capacity.

- Utilities should join this project if they are looking for ways to increase power transfer capability of their thermally limited transmission system, and if they are supporting strategic science and technology development in power transmission. For more information, contact the EPRI Customer Assistance Center (EPRI/CAC) at (800) 313-3774 or Raymond Lings, Area Manager of Transmission and Substations Area, (650) 855-2177, lings@epri.com.

This project contributes to the PIER program objectives of:

- Improving the reliability/quality of California's electricity by enhancing the capabilities of the state's transmission and distribution system. These cables have the potential of increasing the current carrying capability of California's existing transmission corridors beyond their original design capabilities.

Project Status:

The project is behind schedule. EPRI has signed with the 3M corporation to supply their cable for the demonstration. Other cable manufacturers still need contracts.

Distributed Utility Integration Test (DUIT)

Contract #: 500-01-033

Contractor: Distributed Utility Associates (DUA)

Contract amount: \$2,049,850

Match amount: \$250,240

Contractor Project Manager: Susan Horgan (925) 447-0604

Commission Contract Manager: David Michel (916) 651-9864

Project Description: The purpose of this project is to advance the state of the art of distributed resources integration and give new insights into distributed energy resource grid support issues. The increasing potential of distributed resources in emerging utility markets has focused attention on two critical issues: interconnection of distributed resources with electric distribution systems, and the unknown nature of potential interactions between multiple distribution devices. Interconnection is a critical issue because of the diversity of distributed technologies and the variability of interconnection standards and practices from state to state and utility to utility. Another critical issue is that the potential for interactions between distributed resources in close proximity within a distribution system is not known, simply because not enough operating experience has been gained to date.

This Distributed Utility Integration Test is the next step in assuring the safe, reliable, secure and cost-effective inclusion of distributed resources into the electric systems of the future. By collaborating with DUA, the Commission will advance the state of the art of distributed resources integration and strengthen its leadership role in distributed power. By examining current and emerging technologies and operational concepts to properly integrate diverse distributed resources, this project will give new insights into grid support issues and ultimately suggest innovative system protection design concepts.

The goals and objectives of this project are to provide the following:

- Determine what impact large numbers of DER will have on the electrical system;
- Prove the feasibility and the integration of diverse distributed resources in a distribution system; and
- Provide a testing ground for observing and measuring the interactions between the distributed technologies on the distribution system

Achieving these goals and objectives requires full-scale implementation testing and demonstration of distributed generation technologies in an actual utility installation.

This project supports to the PIER program objectives of:

- Improving the reliability/quality of California’s electrical system by advancing distributed generation technologies that will help diversify and strengthen the system.

Proposed Outcomes:

- Develop a DER Procurement Process
- Develop a Test Plan
- Develop specifications for the Test Management Control System
- Design a Data Acquisition System
- Develop software for the Test Management Control System
- Perform the engineering necessary to prepare the facility testing.
- Perform the tests

Project Status:

- Draft DER Test List has been submitted
- Draft Procurement Report is being develop
- Draft Test Plan is being developed
- Draft Test Management Control System Specification is being developed
- Draft Data Acquisition System (DAS) Design Document is being developed
- Draft Facility Engineering Report is being developed

Development/Demonstration of Methodology to Assess Value of Distributed Energy Resources (DER)

Contract #: 500-01-039

Contractor: New Power Technologies

Contract amount: \$616,689

Match amount: \$145,166

Contractor Project Manager: Peter Evans (650) 948-4546

Commission Contract Manager: Linda Kelly (916) 654-4815

Project Description: The purpose of the project is to demonstrate an analytical methodology that can identify where distributed energy resources can provide specific Transmission and Distribution (T&D) network benefits. This methodology will evaluate multiple aspects of network performance including factors affecting stability and power quality in addition to losses. The project will create a detailed and integrated dataset of a utility network that integrates both transmission and distribution.

Once this dataset is accomplished, the project will introduce dispatched loadsheds and embedded generation to see where these additions optimize or improve system performance. This will be achieved through the use of load flow tools traditionally used only for transmission networks, along with new non-linear optimization technologies that simultaneously consider multiple factors and provide repeatable results analyzing systems with large numbers of elements, as is the case with distribution systems. When these locations have been identified and ranked, a portfolio of specific types of DER projects having specific technical and operational attributes that can measurably improve the performance of the utility system will be identified in both engineering and economic terms.

This project will also provide a financial analysis that will allow comparison of these nonwire options to wire options. Additionally, a set of financial and non-financial incentives to facilitate the development of the projects or programs in the portfolio will be developed.

This project contributes to the PIER program objectives of:

- Improving the reliability/quality of California’s electricity system by developing an analytical tool that can identify where DER and other nonwire alternative can be located to help alleviate power quality and T&D capacity and congestion problems in the state; and
- Providing more choices to California consumers by helping overcome the barriers to the deployment of distributed generation.

Proposed Outcomes:

- A detailed and integrated dataset of a utility network that

integrates both transmission and distribution;

- A portfolio of specific types of DER projects having specific technical and operational attributes that can measurably improve the performance of the utility system will be identified in both engineering and economic terms; and
- A financial analysis that will allow comparison of these nonwire options to wire options.

Project Status:

The project Kick-off Meeting was held on September 30, 2002 and the project work is on schedule.

Demand Response Enabling Technologies Development

Contract #: 500-01-043

Contractor: California Institute for Energy Efficiency (CIEE)

Contract Amount: \$3,000,000

Contractor Project Manager: Carl Blumstein 510-287-3320

Commission Contract Manager: Laurie ten Hope
916-654-5045

Project Description: The purpose of this project is to help develop distributed resource (DR) enabling technologies in the medium (3-5 years) and long (5-8 years) term by leveraging on-going RD&D funded in communication, information, and control technologies by other agencies (e.g., the Department of Defense) at UC Berkeley. This contract will focus on specific energy-related tasks that can lead to dramatic decreases in the installed cost of these technologies for DR applications.

This contract will also focus on DR capabilities that are more powerful and robust than those identified in a baseline study also proposed under the DR Program Plan for funding but with a different contractor. Initially, this contract will attempt to develop DR-related:

- a) micro-electromechanical systems (MEMS) sensors and actuators;
- b) open-system, mesh-architecture communication systems that can seamlessly share data;
- c) real-time, distributed-intelligence device networks that are self-organizing; and
- d) enterprise-wide, multi-level control strategies that can absorb legacy systems.

This project supports the PIER Program objectives of:

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

Proposed Outcomes:

A project at the University of California, Berkeley, will begin early in 2003 to leverage existing research funded by the Department of Defense and private industry. Four technologies will form the basis of this medium- to long-term R&D. The proposed work has the potential of reducing statewide DR implementation costs by a factor of 10 while at the same time increasing functionality also by a factor of 10. The results of this R&D will be new reference designs for sensors, meters, thermostats, network management tools, system integration designs, etc., that will make the DR infrastructure very cost-effective and compatible with legacy systems.

Status:

Project start-up activities have begun.



Composite Reinforced Aluminum Conductor (CRAC)

Contract #: 500-00-003

Contractor: W. Brandt Goldsworthy & Associates, Inc.

Contract amount: \$1,100,479

Match amount: \$325,000

Contractor Project Manager: Michael Winterhalter
(310) 375-4565

Commission Contract Manager: Jamie Patterson
(916) 657-4819

Project Description: The purpose of this project is to continue research begun under PIER contract number 500-98-035 with the same contractor. Under the first PIER contract, the contractor successfully completed a \$75,000 research effort to determine the feasibility of using a composite reinforced aluminum conductor (CRAC-TelePower) in applications dominated by the standard aluminum conductor, steel reinforced (ACSR). This follow-on research will develop prototype-manufacturing technology for CRAC and demonstrate the conductor's performance on a 2,000-foot (nominal) 3-phase span using Southern California Edison's expertise. The new conductor has advantages of higher amp loading for the same cost as ACSR, and the potential for carrying digital and analog signals for communications and conductor diagnostic purposes.

Phase II is evaluating manufacturing process improvement concepts which may fundamentally affect the CRAC-TelePower conductor price and quality. An example is to review the cost savings made possible with co-mingling the glass/resin material as part of the conductor manufacturing process. Another example is to review the feasibility of individually powder coating the fibers with thermoplastic matrix material at the bushing. This idea, if proven feasible, has so much merit that it may lead to other clean manufacturing facilities in California that could supply the worldwide composites industry with a superior material system.

The goal of this project is to design, develop and demonstrate a combined transmission line power and data transfer concept. Successful demonstration of this concept also includes developing and demonstrating new manufacturing methods needed to make it cost-competitive. This technology can potentially strengthen California's and the Nation's electric power and communications infrastructure. The research will also enable substantial environmental benefits because the technology will result in the ability to reconductor existing lines with a conductor that transfers more power per unit of weight. Many miles of California's overhead electricity transmission lines have reached the end of their service lives or are being stressed beyond their design limits due to load growth and heavy power transfers across longer distances. This technical

development is very timely as the current age of transmission lines ranges from 30–70 years.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by avoiding power outages caused by line sagging and swinging, high winds and ice buildup;
- Improving the energy cost/value of California's electricity by reducing losses and the costs of replacing conductors;
- Improving the environmental and public health costs/risks of California's electricity by reducing the need for new transmission lines and corridors; and
- Improving the safety of California's electricity by significantly reducing the potential for line clearance violations.

Proposed Outcomes:

1. Beta-test CRAC manufacturing technology by producing sufficient, specification-grade CRAC-TelePower conductor to span three phases at 2,000 feet in a real-time power transmission demonstration.
2. Demonstrate the CRAC-TelePower combined power and data transfer concept in a 2,000 foot, 3-phase conductor span. Specific performance targets are:
 - Line Sag: Target is 20 % less line sag over entire operating temperature range
 - Ampacity: Target is 40 % more "Ampacity" compared to ACSR (DRAKE)
 - Magnetic Fields: Target is 50 % reduction in magnetic fields on the ground
 - Damping: Target is increased damping under conditions of galloping and aeolian vibrations
 - Data Transfer: At least 0.5°C accuracy with a spatial resolution of one meter (analog).
 - Fewer than 1 error bits per 10⁹ bits (digital)
3. Determine the feasibility of manufacturing "CRAC-TelePower" for \$1 per product pound.

Project Status:

The project has reached the #2 objective and is going to be demonstrated at the Tennessee Valley Authority this summer.

Reflective Energies

Contract #: 500-00-013

Contractor: Reflective Energies

Contract amount: \$1,501,268

Contractor Project Manager: Edan Prabhu (949) 380-4899

Commission Contract Manager: David Michel
(916) 651-9864

Project Description: The purpose of this project is to provide

a program of monitoring, data collection, analysis, and reporting for selected Distributed Generation (DG) systems chosen for their diversity in relation to generation, the distribution grid, and customer impact concerns. Through this project, information will be disseminated to the Interconnection Workgroup (an industry workgroup), customers, utilities, manufacturers, government and others in the interest of simplifying future interconnections which will help reduce costs.

This project will also develop the specifications for a separately developed California certification database for DG systems that are certified for certain applications. The certification database will also streamline the interconnection process and is expected to reduce costs. In addition, this project will develop an interconnection guidebook that will help developers and Utility Customers to understand the requirements and processes associated with interconnection of DER in accordance with Rule 21. Finally, this project will provide active participation in the IEEE P-1547 Interconnection Standard Workgroup. The Contractor will be acting as co-author for the development of key sections of the new standard.

The goals of this project are to:

- Characterize the electrical effects of DG on the distribution system,
- Evaluate whether Revised Rule 21 has improved the process of interconnection of DG to the electrical system, and
- Assess the potential for simplifying Rule 21 further to expand the types of different applications eligible for a "simplified interconnection".

This project could potentially reduce the cost on interconnection below what was experienced prior to the Revised Rule 21 by 30 percent for units less than one MW and by 15 percent for units equal to or greater than one MW. The project also could potentially reduce the costs associated with delays in approval and installation of interconnection by more than 20 percent for projects less than one MW.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electrical system by determining the power quality and reliability impacts of DG units on the distribution system; and
- Improving the energy cost/value of California's electricity by assessing the cost-effectiveness of interconnecting DG units under the new Rule 21 guidelines.

Proposed Outcomes:

1. Specifications for an electronic interconnection application system.

2. Specifications for a DG-certified equipment database.
3. Recommendations for further refinement to Revised Rule 21.
4. Case studies of up to 12 different DG installations within California.
5. Develop a DG Interconnection Guidebook.
6. Provide technical support for the IEEE P-1547 National Interconnection Standard.

Project Status:

The database specifications have been completed and are being used to develop the online interconnection application system and certified equipment databases that will eventually reside on the Energy Commission's Distributed Energy Resources (DER) website. Additionally, seventeen interconnection workgroup meetings have been supported to further refine Revised Rule 21. Outreach has been initiated to California municipal and cooperative utilities and irrigation districts.

Both Critical Project Reviews have been completed. Seven distributed energy equipment models have been approved as "Rule 21 Certified" while other equipment models continue to apply. Most of the case studies on DG have been installed on the distribution system and are collecting data. Work has begun on the Interconnection Guidebook. Five IEEE P-1547 Meetings have been attended where the National Interconnection Standard has passed a milestone vote and will soon be adopted. Once the national standard is adopted, the Rule 21 Workgroup will revise Rule 21 to reflect the new national standard.

Demonstration of Intelligent Software Agents for Control & Scheduling of Distributed Generation (DG)

Contract #: 500-00-016

Contractor: Alternative Energy Systems Consulting, Inc.

Contract amount: \$499,970

Contractor Project Manager: Gerald Gibson (858) 560-7182

Commission Contract Manager: Jamie Patterson (916) 657-4819

Project Description: The purpose of this project is to demonstrate scheduling of DG or other energy resources in the electricity marketplace. This project will continue research begun under PIER contract number 500-98-040 and will demonstrate using intelligent software agents for control and scheduling of one or more energy resources in a competitive energy market. The goal of the project is to develop the interfaces that allow the software to operate with a variety of equipment in the marketplace. After the interfaces are developed, a feasibility field test with a variety of equipment and various participants will be performed. This feasibility field

test will provide the necessary data on potential savings to entice customers to use this new technology in their products and operations.

The project will provide demonstration software that can be used to facilitate the transfer of this technology into the energy industry. This is an enabling technology that will make it cost effective to have small generation sources available for dispatch by the California independent system operator (ISO). The software allows the generators to be unmanned and remotely dispatched. This software will also work for curtailable loads.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California’s electricity by enabling a greater participation by owners of distributed energy resources through the use of intelligent software agents for control and scheduling of distributed generation. This will reduce distribution system congestion and avoid distribution line losses.

Proposed Outcomes:

A demonstration of intelligent software agents successfully controlling and scheduling distributed energy generation resources.

The technical performance objectives of this project are to:

1. Update the Smart*DER product specification based on feedback received during the Phase I effort as well as changes that have occurred in the California energy marketplace.
2. Identify and enlist participation by one or more potential commercialization partners that will integrate Smart*DER into their technology for the field test.
3. Refine Smart*DER technology to reflect changes in the product specification and to provide interfaces with field test participant’s software/products.
4. Complete a successful feasibility test assessment of Smart*DER technology scheduling/controlling actual loads and/or distributed generation assets in the "real world" California marketplace.

The economic performance objective of this project is to:

- Identify and engage one or more partners for continued commercialization of the Smart*DER technology.

Project Status:

The project is behind schedule but has completed technical objectives 1, and 3. The unexpected demise of direct access in California has made a demonstration project unlikely, so the contractor has expanded the search for demonstration sites beyond the state borders. Interest has been shown by the City

of Ft. Collins Colorado, both the utilities serving the area, and their customers in demonstrating this software with distributed energy resources. This potential demonstration could include up to 10 sites consisting of Distributed Generation, Demand Response load shedding, and optimized operation of a Thermal Energy Storage system. One possible Distributed Generation site is a biogas-powered generator that will be operated to make maximum use of the limited supply of biogas. This will be a demonstration of enabling technology crosscutting the PIER program areas of Distributed Generation, Demand Response, and Renewables.

Advanced Switches for Soft Blackouts

Contract #: 500-00-018

Contractor: California State University, Chico Research Foundation

Contract amount: \$800,000

Contractor Project Manager: Bill Wattenburg (925) 938-5955

Commission Contract Manager: Mark Rawson (916) 654-4671

Project Description: The purpose of this project to research methods to lessen the impact of rolling blackouts that can occur in California during Stage 3 power emergencies. During previous Stage 3 power emergencies rolling blackouts have been instituted to prevent total electric system collapse. These blackouts are very expensive to California residents and businesses and are done in a disruptive manner. The process presently disables many critical public safety functions such as traffic signals and streetlights and other public safety functions. This project will allow the state to control rolling outages in a less intrusive manner by accomplishing necessary emergency load reduction while allowing lighting, traffic lights, streetlights and other similar public safety devices to continue operating during "soft blackouts."

The objective of this project is to test Advanced Switches for Soft Blackouts. These switches are designed to turn off 240-volt appliances, while leaving 120-volt circuits on.

The goal of this project is to determine the impacts and consequences of opening one hot leg of 240-volt electric service on electrical appliances and equipment normally found in a residence. The project will also determine the impacts and consequences of connecting both legs of a standard residential service to one side of the transformer, effectively reducing residential service to 120-volts. Finally, the project will determine the effect of doing this to an entire house and group of homes.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electrical system by reducing the impact of electric power outages.

Proposed Outcomes:

- Determine the technical and economic feasibility of using these advanced switches to implement soft blackouts versus complete blackouts during Stage three power emergencies.

Project Status:

The Contractor has determined that many household appliances can be safely operated on reduced voltages, but more importantly that appliances are not damaged when this occurs. Also, one configuration of the advanced switch can be used on distribution transformers is not technically feasible and that only the meter socket version is feasible. Now, research will be focused on just the meter socket version and its implications for household circuits and groups of homes. Additionally, the contract will be amended to look at power line carrier technology to dispatch the meter socket versions of these advanced switches.

Seismic Studies

Contract #: 500-01-025 **Project #:** 1

Contractor: Electricity Innovation Institute (E2I), EPRI

Project amount: \$22,400

Match amount: \$20,000

Contractor Project Manager: Ben Damsky (650) 855-2385

Commission Contract Manager: David Chambers
(916) 653-7067

Commission Contract Manager: Gary Klein, (916) 653-8555

Project Description: The purpose of this project is to seismically qualify substation equipment in accordance with the new IEEE Standard 693, IEEE Recommended Practice for Seismic Design of Substations. This project is needed to reduce costs by combining resources to qualify the equipment, and to have equipment that is pre-qualified so that facility construction is not delayed due to qualification. It will also qualify equipment that has the most vulnerable configuration so that other equipment variations can be qualified by similarity methods. A consortium of utilities will provide guidance to the project. Testing will be performed at appropriate test facilities as directed by the consortium.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by qualifying substation equipment to meet the IEEE Standard 693; and
- Improving the safety of California's electricity by providing utilities access to equipment that has been qualified in

accordance with the standard.

Proposed Outcomes:

1. Develop improved seismic procedures for conducting shake-table tests on selected equipment.
2. Verify compliance of selected substation equipment with IEEE Standard 693.
3. Understand deficiencies of the standard for the qualification of transformer bushings and propose improvements.

Actual Outcomes:

1. Selected test facility, prioritized order of tests, established equipment support structure specifications, defined vibration test requirements, and determined specifications for electrical equipment and tests.
2. Tested and qualified eight CVTs from two manufacturers, including a 230-kV porcelain unit, a 500-kV porcelain unit, three types of 230-kV composite units, and three types of 500-kV composite units.
3. Established the groundwork for testing and qualifying disconnect switches. This includes developing a support structure for the 230-kV switches, identifying switch manufacturers willing to participate, and developing an RFP to go to manufacturers.
4. Two models of transformer bushings have been developed that indicate that a more detailed model is needed.

Project Status:

Commission staff are participating in the project. A follow-on two-year project, starting in 2003, is planned.

High Temperature, Low Sag Conductor

Contract #: 500-01-025 **Project #:** 2

Contractor: Electricity Innovation Institute

Project amount: \$112,000

Match amount: \$100,000

Contractor Project Manager: Raymond Lings
(650) 855-2177

Commission Contract Manager: Jamie Patterson
(916) 657-4819

Commission Contract Manager: Gary Klein, (916) 653-8555

Project Description: The purpose of this project is to evaluate the performance of selected "high-temperature, low-sag" conductors that are capable of significantly increasing the ampacity of thermally constrained transmission lines without the need for extensive tower redesign. Examples include 3M, CRAC, and Gapped conductors, and commercial forms of aluminum steel-supported conductors (ACSS) such as ACSS-TW.

The majority of overhead transmission lines currently use steel-reinforced aluminum conductors (ACSRs). ACSRs can be routinely operated at temperatures up to 100 degrees Celsius (212° F) and, during emergencies, at temperatures as high as 150 degrees Celsius (302° F). Today, however, power industry deregulation is placing new demands on the delivery system and altering high-voltage transmission network power flow patterns. Consequently, networks are increasingly being forced to support power flows and transfer capacities for which they were never designed.

One approach to addressing this dilemma would involve upgrading the transfer capacity through reconductoring selected network lines. In recent years, conductor manufacturers have produced new, nontraditional conductors capable of operating at temperatures as high as 250 degrees Celsius (482° F) without violating present electrical clearances to ground and other objects. While these conductors have passed accepted industry standards tests for performance, utilities are wary of installing these yet unproven technologies without having first gained an insight into their performance in a real-world setting.

The project will provide the participating utilities with information on the operational performance of these new conductors through approximately three years of field trial experience and laboratory tests that will be specified and paid for by the project's participating utilities. In addition, the project will evaluate the performance of conductor fittings -- including splices and dead-ends -- in both field and laboratory tests.

Further, the project will compile practical "engineering-type" information to aid utilities in designing, specifying, installing, inspecting, and maintaining the conductors. The results will position participating utilities as informed buyers and users of the technology.

This project contributes to the PIER program objective of:

- Improving the reliability/quality of California's electricity by enhancing the capabilities of the state's transmission and distribution system. These cables have the potential of increasing the current carrying capability of California's existing transmission corridors beyond their original design capabilities.

The objective of this project is to provide answers to questions, such as:

- How do manufacturer claims compare to field and laboratory performance?

- What are the design parameters for these conductors?
- What engineering changes are necessary when replacing existing conductors with these products?
- What is the impact of these conductors on existing tower design?
- What special handling precautions apply?
- How do these new conductors age, and what factors influence aging?
- What is the long-term performance of line hardware?
- How do conductor fittings perform under high temperature over long periods?
- What are the costs of operation and lifetime costs, and how do these costs compare to the existing transmission infrastructure O&M costs?
- What inspection techniques should be used?
- What engineering guidelines and training materials are required?

Participants in this project will be able to take advantage of the following deliverables:

- Project review meetings, held twice a year, plus monthly and quarterly updates. At these meetings, progress will be reported and revisions to the plan discussed.
- Field and laboratory test results: Progress reports will be generated after every sampling period.
- Technical workshops: Workshops will be conducted on specific engineering and technical aspects. Examples may include visits to manufacturers, site visits, observation of fieldwork, and training for designers and field personnel.
- Final project report and workshops: The final report will include a summary and analysis of the field and laboratory results. Results will be presented to funders at a final project workshop.

Participants will have the benefit of gaining first-hand experience on the installation and operation of "high-temperature, low-sag" transmission conductors. Host utilities will have the "high-temperature, low-sag" transmission conductor installed in their transmission system, benefiting from its higher thermal rating capacity.

Utilities should join this project if they are looking for ways to increase power transfer capability of their thermally limited transmission system, and if they are supporting strategic science and technology development in power transmission. For more information, contact the EPRI Customer Assistance Center (EPRI/CAC) at (800) 313-3774 or Raymond Lings, Area Manager of Transmission and Substations Area, (650) 855-2177, lings@epri.com.

Project Status:

The project is behind schedule. EPRI has signed with the 3M corporation to supply their cable for the demonstration. Other cable manufacturers still need contracts.

Program 38-Transmission & Substation Asset Utilization

38.001 Flexible AC Transmission System (FACTS)—
Convertible Static Compensator

38.010 Flexible AC Transmission System (FACTS)—
Information Sharing & Technology Updates

38.011 Identify Transmission Throughput Bottlenecks,
Review/Update Static Ratings, and Migrate to Quasi-Dynamic
Ratings

Contract #: 500-00-023 **Project #:** 47-49

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$78,518

Match amount: \$191,029

Contractor Project Manager: Aty Edris (650) 855-2311

Commission Contract Manager: Don Kondoleon
(916) 654-3918

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: This purpose of this project is to demonstrate an advanced controller technology with the potential to substantially increase power transfer capability on the transmission grid in California and the western region. The Convertible Static Compensator (CSC) is the latest FACTS (Flexible Alternating Current Transmission System) Controller developed under EPRI's FACTS technology development and application program. The CSC is an innovative power electronics-based controller that provides multiple compensating modes, which are needed to securely increase power transfer capability limits of existing transmission systems. The Controller provides flexible dynamic voltage control (to avoid voltage instability), as well as simultaneous real and reactive power flow control on multiple transmission corridors (without risk of transient or dynamic instability). The CSC offers this flexibility by allowing its converters to be connected in shunt, in series, in shunt/series, or in series/series with two lines.

This EPRI project supports demonstration of the world's first CSC—two 100-MVA Voltage Source Converters—which has been installed and is in operation at New York Power Authority's (NYPA's) Marcy Substation in Utica, New York. The CSC is enabling NYPA to mine 240 more MW of power from the grid precisely when they need it most—during contingency situations. Membership in this project provides the Energy Commission with key technical information on installation and operation of the CSC, and integration of the CSC in a power

grid.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system; and
- Improving the safety/reliability of California's electricity system by developing technologies to maintain and enhance system security in the face of increasing traffic and congestion, while avoiding the environmental impacts associated with new transmission lines and corridors.

Proposed Outcomes:

1. Install CSC voltage source converters for shunt and series compensation.
2. Conduct initial field tests.
3. Deliver industry updates on FACTS and FACTS-related activities.
4. Provide practical guidelines to identify potential transmission bottlenecks, identify measurement locations, perform data analysis to determine line performance under adverse conditions, update/revise static ratings, and (if appropriate) implement quasi-dynamic ratings for lines that do not require installing permanent real-time dynamic thermal circuit rating tools.

Actual Outcomes:**Convertible Static Compensator**

- Phase 1 of the project, shunt operation modes providing + Mvar reactive support at the Marcy substation, is complete. The CSC in shunt operation modes is in service.
- Record and analysis of the CSC operating performance is an ongoing process.
- Phase 2 of the project, which includes installation of two series transformers and six bypass switches, is in progress.
- Commissioning tests of the series operation modes are scheduled for January 2003.

Information Sharing and Technology Updates

- A website named eprifacts.com is currently under development. The website is structured to provide: background information, tutorial information on the FACTS technology concept, benefits assessment, description of the installed FACTS controllers, articles, and what's new/news and announcements.
- Work is under way to add a link for web-based simulation tool, a three-area transmission network allowing simulation of STATCOM, SSC, and/or UPFC at arbitrary location with different ratings.
- The 5th FACTS User's Group meeting was held on October

23-25, 2002 in San Diego, CA. A CD-ROM documenting all presentations is available.

Identify Transmission Throughput Bottlenecks

- A technical progress report—*Quasi-Dynamic Rating Pilot Study* (1001830)—was published.
- EPRI Solutions has collected the DTCR data from LIPA-Long Island Power Authority, which were used for developing the methodology for Quasi-Dynamic Ratings.
- This project was reviewed at the last IPF Task Force meeting, August 8-9, 2002 in Minneapolis, MN and will be reviewed again at the next IPF Task Force Meeting, January 16-17, 2003, in Atlanta.

Project Status:

Commission participation in these EPRI projects is ongoing.

Development of a Real-Time Monitoring/Dynamic Rating System for Overhead Lines

Contract #: 500-98-034

Contractor: Engineering Data Management, Inc.

Contract amount: \$499,402

Match amount: \$510,019

Contractor Project Manager: Andrew Stewart
970) 204-4001

Commission Contract Manager: David Chambers
(916) 653-7067

Project Description: The purpose of this project is to develop a monitoring system that provides instantaneous information to electric grid operators about monitored transmission lines' power-carrying capacity and safety code compliance. The system will provide real time monitoring to ensure power line ground clearance requirements are met and calculates the maximum power transfer capability of monitored lines based on actual position of the conductor. Assuring maximum power transfer capability over existing lines increases the efficient use of overhead transmission lines and reduces the need for new power lines.

This project improves the safety and the reliability of California's electrical transmission and distribution infrastructure by providing a system able to monitor transmission line-to-ground clearance thereby avoiding fires and electrical shock hazard and reducing power outages caused by sagging lines.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by

providing a system to reduce power outages caused by sagging lines;

- Improving the energy cost/value of California's electricity by improving the efficiency and power carrying capability of monitored lines and reducing costs of power delivery;
- Improving the environmental and public health costs/risks of California's electricity by reducing need for new transmission corridors and avoiding fires; and
- Improving the safety of California's electricity by monitoring transmission line-to-ground clearance thereby avoiding electrical shock hazard.

Proposed Outcomes:

- Improving the ability to monitor the line to ground clearance of transmission lines.
- Reduce energy cost by improving the efficiency and power carrying capability of monitored lines.
- Ability to measure clearances and sags with an accuracy of better than ± 2 inches.
- Capable of threefold use:
 - Real-time monitoring/dynamic rating;
 - Evaluating the performance of existing lines to re-rate their capability; and
 - Monitoring the status of clearances/sags in "safety critical" areas.
- Installation time for sensor system field hardware of less than six hours.
- Capable of operation in remotes sites through use of solar power supply plus capability for simple reconfiguration to AC power.
- Capable of reliable operation during daylight and at night.
- Capable of reliable operation in temperatures ranging from -10 degrees F to $+120$ degrees F.
- Capable of ready integration of additional devices for making ancillary measurements such as wind speed and ambient temperature.
- Capable of remote sensor system operation through cellular, radio, or satellite communication.
- Capable of autonomous remote reboot of hardware in case of an operational or environmental anomaly that causes proper operation to cease.
- The target maximum cost for a complete system is \$45,000

Project Status: The project is on schedule to finish within the contract term. The fabrication of sensors is complete. Integration and evaluation of the system in the laboratory is completed. The System is now under going field-testing. To date, no significant problems have been encountered that materially affect the project budget.

2 kWh Flywheel Energy Storage System

Contract #: 500-98-036

Contractor: Trinity Flywheel Power Corp

Contract amount: \$1,057,406

Match amount: \$1,062,494

Contractor Project Manager: Melissa Reading
(925) 455-7998

Commission Contract Manager: Jamie Patterson
(916) 657-4819

Project Description: The purpose of this project is to demonstrate a two-kWh flywheel energy storage system for distributed generation and load shifting that will be directly scaleable to ten kWh. This will be achieved through the design, fabrication, and operation of a cost-effective composite flywheel having both high specific energy and low idling losses. The product itself will comprise the integration of a flywheel motor generator together with the power electronics, resulting in a 2 kWh flywheel energy storage system. A flywheel energy storage system will be able to store electricity at the customer's site, lessening the impacts of interruptions to customer loads.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by providing a load shifting technology that can be used during peak load periods.

Proposed Outcomes:

- One operating two-kWh flywheel energy storage system for distributed generation and load shifting that will be directly scaleable to ten kWh.
- Complete the transition from further development of the technology to volume manufacturing.

The technological objectives of this project are to:

- Produce a 2 kWh Flywheel Motor Generator with a rotor diameter not to exceed 16 inches, having a length not exceeding 32 in.
- Test and demonstrate a flywheel energy storage system installed within a cabinet not to exceed 48 inches wide, 36 inches deep and 80 inches high. The performance objectives of the flywheel energy storage system are:
 1. Usable storage of not less than 2 kWh;
 2. Maximum output power greater than or equal to 5kW; and
 3. A rated output of 2kW.

The economic objective of this project is to have a production cost of \$30,000/kWh, or less, for production volumes of one to ten units.

Project Status:

The project is proceeding under a revised schedule due to the inability of the initial subcontractors to deliver a product. Fortunately, AFS Trinity had the expertise to design and construct an inverter in-house. This has helped to keep the costs within budget. There appears to be no manufacturer that can supply a commercially viable composite rotor capable of storing two kilowatt-hours of energy at a reasonable cost. This represents an area for further research. This project will only be able to develop a 400 watt-hour flywheel that is saleable. Interest has been expressed by several fuel cell manufacturers to use this flywheel in their product to supply load following capability.

Sagging Line Mitigator (SLiM)

Contract #: 500-98-042

Contractor: Material Integrity Solutions, Inc.

Subcontractors: Dr. Duch Hai Nguyen of Hydro Quebec (IREQ) : Dariush Shirmohammadi, Ph.D. : Expert Power Engineering Consultant.

Contract amount: \$900,000

Match amount: \$304,833

Contractor Project Manager: Manuchehr Shirmohamadi
(510) 594-0300

Commission Contract Manager: David Chambers (916) 653-7067

Project Description: The purpose of the SLiM project is to develop and test a sagging line mitigator to automatically counteract the sagging of high voltage transmission lines due to high ambient temperature and current flows. The product to be developed has the potential to revolutionize treatment of overhead transmission lines for both retrofitting of existing lines and construction of new lines. It will significantly reduce the risk of forest fires and brownouts caused by sagging lines, increase the efficiency of energy transfer, delays the need for additional line capacity and delay the construction of new lines. Used on new lines, this product will allow reduced tower height and/or increased distance between towers.

This project supports the PIER Program objectives of:

- Improving reliability and quality of California's electricity system by reducing the risk of brownouts (the curtailment of electric deliveries due to line constraints) and power supply interruptions;
- Improving the safety of California's electricity by significantly reducing the risk of electrocution and fires caused by sagging transmission and distributions lines; and
- Reducing the environmental and public health risks/costs of California's electricity system by avoiding the need to build additional transmission towers.

Proposed Outcomes:

- Complete design and analysis work for the proposed SLIM device;
- Conduct rigorous prototype testing for applicability, proof of concept and design refinements; and
- Develop manufacturing plans for the SLIM device.

Project Status:

The project is on schedule, within budget and has achieved the proposed outcomes. The final report is under review for acceptance.

The Valley Group

Contract #: 700-00-006

Contractor: The Valley Group, Inc

Contract amount: \$369,204

Contractor Project Manager: Tapani Seppa (203) 431-0262

Commission Contract Manager: Don Kondoleon
(916) 654-3918

Project Description: The purpose of this project is to demonstrate the feasibility of implementing real-time transmission line ratings for Path 15, which is one of the most complex gates in the California transmission system. Path 15 consists of 6 transmission lines located between central and southern California within PG&E's service territory. This project investigates the feasibility of providing real-time transmission line ratings by monitoring the conductor tension and environmental factors for a multiple transmission line path and communicating the real-time data to PG&E and the system operators at the ISO. This project is also unique because it provides a calculated real-time rating for the path directly to the system operators, as opposed to previous systems that store data for collection and later analysis. Finally, this project will also identify other possible paths in California that could benefit from real-time thermal ratings.

This project supports the PIER Program objectives of:

- Improving the reliability and quality of California's electricity by increasing power transfer capability on an annual basis through Path 15; and
- Improving the energy cost/value of California's electricity by reducing utility expenditures through decreased transmission congestion on Path 15 during peak periods.

Proposed Outcomes:

- Develop software and procedures to allow an increase of thermal capacity of Path 15.
- Verify the applicability of such hardware, software and

methods for use on other thermally limited paths and single circuits in California.

Project Status:

- All tasks have been successfully completed
- Draft final report is currently under review.

Final Results:

- The project was successful in demonstrating the feasibility of implementing real-time ratings for Path 15. The monitors were installed and calibrated, the data was collected and analyzed and results benchmarked against predicted outcomes. Based on the success of this project, PG&E has identified additional critical locations for monitoring and has initiated the installation of additional real-time monitors.

Electric System Seismic Safety & Reliability Study

Contract #: 700-99-002

Contractor: Pacific Gas and Electric Company

Contract amount: \$4,500,000

Match amount: \$5,500,000

Contractor Project Manager: Lloyd S. Cluff (415) 973-2791

Commission Contract Manager: David Chambers
(916) 653-7067

Project Description: The purpose of this contract is to fund user-driven research to support the development and rapid application of methods and technologies for reducing earthquake hazards and vulnerability, and improve electric system reliability and safety of electric transmission and distribution systems. This contract is a continuation of the successful research conducted under contract No. 500-97-010.

PEER (Pacific Earthquake Engineering Research Center) is a consortium of 18 research universities located in California and other western states that has received National Science Foundation support for research in earthquake engineering and related fields. The PG&E-PEER Business and Industry Partnership was formed in 1996 to address, in a user-driven manner, important earthquake issues encountered by electric utilities operating in earthquake-prone regions.

This project supports the PIER Program objective of:

- Improving the safety and reliability/quality of California's electricity by conducting research to enhance the stability of the electric system after major earthquakes. It also contributes to the goal of enhancing local and state economies by minimizing the costs associated with power disruptions after a major earthquake.

Project Status:

The contract term is February 1, 2000 through June 30, 2004. The project is on schedule and budget. As of 01/15/02 there were fifty-three active research projects covering seven topic areas. The topic areas in this project are:

- Earthquake Ground Motion;
- Site Response;
- Permanent Ground Deformation;
- Seismic Performance of Substation Equipment;
- Electric System Building Vulnerability;
- Network System Seismic Risk; and
- Emergency Response.

EPRI Program 35 Overhead Transmission 35.008: Overhead Transmission Line Reference Manuals

Contract #: 100-98-001

Contractor and Major Subcontractors: EPRI

Contract Amount: \$21,538

Match Funding: \$247,683

Contractor Project Manager: Ray Lings, (650) 855-2177

Commission Project Manager: Jamie Paterson (916) 657-4819

Commission Contract Manager: Gary Klein, (916) 653-8555

Project Description: The purpose of this project is to revise EPRI's "Red Book"—the *Transmission Line Reference Book: 345 kV and Above*. The revision will update the handbook to incorporate the latest operating experiences and technologies, and to ensure that the handbook reflects both domestic and international operating practices and work environments. The revision will add new chapters as appropriate.

The Transmission Line Reference Book: 345 kV and Above is recognized worldwide as the leading handbook—the industry standard—on transmission line design. The printed book has a red cover, and has become widely known as the "Red Book" in the industry. The first edition was published in 1975, the second edition in 1982, and the second revised edition in 1987. It has not been revised since then.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through updating of the premier guide to transmission line design.

Proposed Outcomes:

- Rewrite and update the book as necessary to incorporate the latest operating experiences and technologies, and to ensure that the handbook reflects both domestic and international operating practices and work environments.

Actual Outcomes:

1. The actual re-write of chapters has started. Around 40% of the book was re-written in this year and the rest will be rewritten in 2003.
2. In August 2002, the various team members met to review progress and to debate face-to-face the structure of various chapters. An advanced draft of the chapter on Electromagnetics was presented, along with a number of "applets"—small software routines designed to demonstrate concepts within the book. Chapter outlines covering Lightning, Live Working, Radio Noise, Audible Noise, Corona Fundamentals and Corona Loss were presented and debated.
3. The editorial panel was formed and met in August.
4. A report was published entitled *Updating the EPRI Transmission Line Reference Book (Red Book)—2002 Progress Report* (1001762), which summarizes progress to date.
5. Additional contracts will be placed for work to start in early January 2003.
6. In January 2003, a review meeting will be held. At that meeting, draft chapters will be presented on Lightning Performance, Corona Phenomena, Radio Noise, and Audible Noise.

Project Status:

Commission participation in this EPRI project is ongoing.

CERTS Demand Response Amendment

Contract #: 150-99-003 **Project #:** 2

Contractor: Lawrence Berkeley National Laboratory

Project amount: \$895,000

Contractor Project Manager: Judie Porter (303) 444-4149

Commission Contract Manager: Don Kondoleon (916) 654-3918

Project Description: The purpose of this project is to address the transition of California's electricity supply and delivery infrastructures from vertically integrated, utility-controlled organizations to deregulated, market-driven institutions. Power supply, network management and control systems are being driven to find new solutions to the traditional methods used to ensure stable power flows, frequency and voltage control. This project will provide integrated research and technology development that will help produce quicker and more flexible options for meeting the reliability, stability and ancillary service needs of California's electricity consumers

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity infrastructure by finding new solutions for a continued stable

power supply for a deregulated electricity market; and

- Improving the energy cost/value of California’s electricity by increasing the efficiency of California’s competitive electricity market.

Proposed Outcomes:

- Identify and define priorities for publicly-funded reliability research needed to support a restructured California electricity industry;
- Complete research in the area of real time system management that will allow California’s interconnected power system to operate closer to its actual physical and stability limits;
- Complete research in the area of integration of distributed resources needed to capture the full potential of distributed resources to maintain or improve the reliability of the California interconnected power system; and
- Complete research in the area of reliability and markets needed to ensure that a fair and transparent market for ancillary services will efficiently and reliably serve California energy consumers.

Project Status:

- Interviewed CAISO managers as input to the grid of the future activity;
- Completed functional and design specifications for ancillary services monitoring, tracking and prediction tool for CAISO;
- Installed VAR monitoring, tracking and prediction tool at CAISO;
- Installed post-disturbance assessment tool at CAISO;
- Developed automatic display builder for CAISO station diagrams;
- Completed functional specifications for interfacing real-time and historical data at CAISO;
- Developed and installed short-term load forecasting tool at CAISO; and
- Installed operating training simulator at CAISO.

Center for the Study of Electricity Markets

Contract #: PIR-00S-001

Contractor: University of California, Energy Institute
Center for the Study of Energy Markets

Contract amount: \$2,050,000

Match amount: \$200,000

Contractor Project Manager: Severin Borenstein
(510) 642-5415

Commission Contract Manager: Mike Jaske (916) 654-4777

Project Description: The purpose of the grant agreement is for University of California Energy Institute (UCEI) to operate a

Center for the Study of Energy Markets (CSEM) to undertake market performance research. Tasks to be performed by the CSEM are divided into 4 categories relating to program management, the performance of research, and the presentation and transfer of research results. CSEM will contribute a diverse array of products useful to decision-makers and the market alike.

The central mission of CSEM is for UCEI staff, UC professors and students, and visiting professors to produce high quality research on the design, performance, and analysis of energy markets. The thrust of CSEM research will be towards more basic research in these areas. Research at CSEM will focus on developing new tools and strategies for the analysis of electricity markets.

Over the period of the grant, CSEM will conduct research in five areas:

1. The reliability in a market-based industry structure;
2. The interaction of demand response and market competitiveness, the political economy of distribution/retail rate structures, and the feasibility and impact of various proposals for providing customer response;
3. The development of tools to analyze the impact of market design on the ability of firms to exercise market power and the ability of decentralized market activities;
4. Systematic analyses of both the benefits and consequences of the various tools for mitigating market power that have been proposed or adopted in electricity markets around the world; and
5. Interactions between electricity markets and environmental regulation.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California’s electricity system by providing assessments of major market structure and performance issues that are a key part of the macro environment influencing the commercialization and adoption of energy technologies.

Project Status:

The grant has been operating for about 18 months. A significant modification, resulting from the start up delays, has been to extend the term of the agreement to cover nearly four calendar years, recognizing that relatively little was accomplished in the initial startup period, and relatively modest expenditures were made. On net, slightly greater number of deliverables will be achieved under this no-cost, term extension than under the original grant. All startup activities have been successfully completed, and CSEM is in full operation.

During 2002, CSEM was able to attract two energy researchers to the UCEI facility for a period of in residence research. These were Frank Wolak of Stanford and June Ishi of UC-Irvine. Several graduate and post-doctoral students are now supported. Several additional ones were scheduled for spring 2003, and in the fall a recruitment effort was launched for the 2003/04 academic year.

During 2003, CSEM personnel have prepared several research and policy papers as required by the grant terms. These were "published" on the UCEI website under the CSEM Working Paper Series, which replaces the long time POWER Working Paper series.

More importantly, the technical transfer tasks within the grant have become functional. CSEM conducted a major technical conference (POWER conference, March 2002) and a new policy conference (held at the CEC on November 2002). The policy conference was attended by about 85 CEC, CAISO, CPUC, other agency and legislative staffers was seemed well received by participants. In addition, CSEM sponsors periodic seminars at UC-Davis and UC-Berkeley where researchers present interim and preliminary results in an academic seminar setting. Finally, in the late fall CSEM personnel began marketing efforts for an "executive education" style short course on energy markets to be held in January 2003.



Target 38A Flexible AC Transmission Systems

Contract #: 500-00-023 **Project #:** 16

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$62,500

Match amount: \$274,237

Contractor Project Manager: Aty Edris (650) 855-2311

Commission Contract Manager: Don Kondoleon
(916) 654-3918

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to demonstrate an advanced controller technology with the potential—if it were applied—to substantially increase power transfer capability on the transmission grid in California and the western region. The Convertible Static Compensator (CSC) is the latest FACTS (Flexible Alternating Current Transmission System) Controller developed under EPRI's FACTS technology development and application program. The CSC is an innovative power electronics-based controller that provides multiple compensating modes, which are needed to securely increase power transfer capability limits of existing transmission systems. The Controller provides flexible dynamic voltage control (to avoid voltage instability), as well as simultaneous real and reactive power flow control on multiple transmission corridors (without risk of transient or dynamic instability). The CSC offers this flexibility by allowing its converters to be connected in shunt, in series, in shunt/series, or in series/series with two lines.

This EPRI project supports demonstration of the world's first CSC—two 100-MVA Voltage Source Converters—which has been installed and is in operation at New York Power Authority's (NYPA) Marcy Substation in Utica, New York. The CSC is enabling NYPA to mine 240 more MW of power from the grid precisely when they need it most—during contingency situations. Membership in this project provides the Energy Commission with key technical information on installation and operation of the CSC, and integration of the CSC in a power grid.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system; and
- Improving the safety/security of California's electricity system by developing technologies to maintain and enhance system security in the face of increasing traffic and congestion, while avoiding the environmental impacts associated with new transmission lines and corridors.

Proposed Outcomes:

1. Install CSC voltage source converters for shunt and series compensation.
2. Conduct initial field tests.

Actual Outcomes:

- Phase 1 of the project (Static Synchronous Compensator [STATCOM] operation) was successfully commissioned in June this year.
- CSC in the shunt operation modes (+/-200 Mvar STATCOM) is now in service, and is being monitored for fine-tuning the control and protection system.
- A dedication ceremony was held June 21 to mark the startup of the first phase of the CSC.
- A technical progress report Convertible Static Compensator (CSC) for New York Power Authority, EPRI no. 1001970, was published.
- A review of the CSC operation was presented at the FACTS Users Group Meeting on October 18-19, 2001 in New York City.
- An EPRI "Innovators" document, quantifying the benefits of the CSC, is currently under development and will be published by the end of December 2001 or early January 2002.
- Work is under way on the series operation modes—Static Synchronous Compensator, Unified Power Flow Controller, and Interline Power Flow Controller.
- Installation of two bypass switches is under way.

Project Status:

Commission participation in this target is complete.

Target 39 Grid Operations and Management

Contract #: 500-00-023 **Project #:** 17

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$201,923

Match amount: \$5,156,709

Contractor Project Manager: Stephen Lee (650) 855-2486

Commission Contract Manager: Don Kondoleon
(916) 654-3918

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to support EPRI's collaborative program in Grid Operations and Management, which is developing new tools and information that could be used to more efficiently and reliably operate the electricity power grid in California and the western region. EPRI products enable power system operators to cost-effectively upgrade systems, merge databases from different sources, exchange information in real time, and better manage systems

during and following emergencies. To ensure the grid is capable of supporting the competitive market, EPRI software also offers capabilities for more accurately estimating and monitoring power system transactions. In addition, as the number and scale of transactions on the California grid increase, and as system security is challenged, EPRI provides new information and approaches for ensuring the reliability of the system.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system; and
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Provide software and information to reduce the costs and improve the efficiency of control center operation.
2. Provide software, methods, and information to enhance the transaction without impact on security.
3. Provide new methods and information to improve the security of the system and avoid management capabilities of transmission system operations, and to allow increased transactions system failures.

Actual Outcomes:

1. Reduce the Costs and Improve the Efficiency of Control Center Operations
 - Three sets of tests were conducted that demonstrated a common language for information sharing among utility applications. In the tests software vendors exchanged versions of the Common Information Model (CIM) translated into the industry standard eXtensible Markup Language (XML), which permits the exchange of power system models in a format that any Energy Management System can understand using Internet or Microsoft technology.
 - A proposal was developed for a CIM standard, which would permit assembling diverse sources of enterprise data into a common database.
 - Two reports were produced on changes necessary to the existing standard for the real-time standard for data exchange.
 - Version 2.0 of EPRI's GOP Graphics System was developed

and tested. The software, which provides a standard Graphical User Interface (GUI) for any EPRI grid operations software, was upgraded to allow remote access to applications.

- Two products were developed to educate operators in emergency system management and restoration: the Tutorial for System Restoration and Version 2.0 of the Operator Training Simulator (OTS).
 - *Instructor Guidelines for Use of an Operator Training Simulator* was published.
 - A tri-annual newsletter was published on new software programs and methods for improved transmission grid operation.
2. Enhance Transaction Management
 - Two reports were published on design specifications for a Topology Estimator and a beta version of Topology Estimator software was developed. This product will enable accurate estimate of the real-time network topology status, which is crucial for correct scheduling of generations and transactions.
 - EPRI participated in industry collaborative efforts to develop electronic scheduling capabilities, including Version 1.4 of the transaction management software Open Access Same-time Information System (OASIS) software.
 3. Improve System Security
 - A report was published that summarizes the 15 major accomplishments of EPRI's Security Mapping and Reliability Index Evaluation (SMRIE) project, which provides system operators with the capacity to monitor security levels quickly and accurately.
 - A report was published that describes on-line capabilities for detecting high-risk, or N-k, contingencies that result in unscheduled outages of multiple components within bulk high-voltage electric transmission systems.
 - A report was published that provides a systematic procedure for determining the effects on an entire power network of hidden failures in protection systems.

Project Status:

This project is complete.

Target 40 Grid Planning and Development

Contract #: 500-00-023 **Project #:** 18

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$98,077

Match amount: \$4,282,593

Contractor Project Manager: Stephen Lee (650) 855-2486

Commission Contract Manager: Don Kondoleon (916) 654-3918

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to increase the speed and efficiency of planning tools. Grid planning cycles today in California and throughout North America are continually being compressed. To make effective decisions under these conditions, power system planners need tools that allow them to rapidly obtain and process information, solve complex problems, and, in some cases, provide a sound business justification for their decisions. In addition, planners must often seek to maximize the value of their power grid assets while at the same time maintaining system reliability.

EPRI products in this area are designed to meet new grid planning needs in California and elsewhere by increasing the speed and efficiency of planning tools. For example, one product will help planners take advantage of advances in grid operations tools by improving capabilities for sharing real-time data with grid operations applications. Other products are increasing capabilities of existing software for simulation and analysis of grid conditions. EPRI is also strengthening capabilities for evaluation of grid security and providing new tools for conducting cost/benefit studies. The one-day workshop sponsored by this target in association with the Energy Commission provided a large public forum for evaluation of alternative wholesale market structures for California.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system; and
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Develop and upgrade grid planning software and methods to increase the speed and efficiency of their analytical capabilities and improve their ease of use.
2. Enhance grid planning software used for assessing transmission system reliability.
3. Improve grid planning software with capabilities for cost/benefit analyses of network additions and constraints.
4. Conduct a cofunded project entitled "Workshop on Exploring Alternative Wholesale Market Structures for California."

Actual Outcomes:

1. Improve Software Efficiency and Ease of Use
 - Two mainline planning applications—IPFLOW and DYNAMICS—were integrated with a database compliant with the Common Information Model (CIM), enabling these planning applications to utilize real-time operating data and share data with operators.
 - New computational techniques to increase analysis speed were developed for a restructured version of the Electromagnetic Transients Program (EMTP), a software widely used for simulating and identifying solutions for high-speed transients. *Restructured Electromagnetic Transients Program*
 - *Progress Report: (EMTP-RV) (1001989).*
 - Object-oriented technology was applied to the Power Systems Analysis Package (PSAPAC) software, which will increase the processing efficiency and substantially reduce the cost of development.
 - Version 6.0, incorporating an improved graphical user interface, was developed for the Interactive Power Flow (IPFLOW) program, which supports a family of planning applications, including ETMSP, VSTAB, and SSSP.
 - Version 2.0 of EPRI's GOP Graphics System was developed, providing a standard graphical user interface for all EPRI grid planning applications.
 - Software support was provided to users of EPRI's grid planning and development software, including ongoing distribution and maintenance, user group support, and software enhancements.
 - A triannual newsletter was published on new software programs and methods for improved transmission grid planning.
2. Strengthen Capabilities for Reliability Assessment
 - A report—*Restructured Transmission Reliability Evaluation for Large-Scale Systems (TM) (TRELSS (TM)): An Implementation Plan (1001987)*—was published on progress in upgrading EPRI's Transmission Reliability Evaluation for Large-Scale Systems (TRELSS)—commonly used for assessing reliability of bulk power systems—to update its computational techniques, GUI, database management, and use of object-oriented technology.
 - A report - *Modeling and Diagnosis Methods for Large-Scale Complex Networks: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report (1006092)*—was published that presents progress on modeling and diagnosis methods for large-scale complex networks.
 - A report - *Intelligent Management of the Power Grid: An Anticipatory, Multi-Agent, High Performance Computing Approach: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report (1006091)*—was published that describes the progress

made in understanding the grid as a customer-driven, anticipatory system.

- A report - *Minimizing Failures While Maintaining Efficiency of Complex Interactive Networks and Systems: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report* (1006093) - was published that discusses minimizing failures while maintaining efficiency of complex interactive networks and systems.
 - A report - *Context-Dependent Network Agents: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report* (1006094) - was published that presents progress on developing and demonstrating "context-dependent network agent" (CDNA) technology.
 - A report - *From Power Laws to Power Grids: A Mathematical and Computational Foundation for Complex Interactive Networks: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report* (1006095) – was published that focuses on understanding the behavior of large-scale complex interactive networks and investigating their mathematical underpinnings.
3. Enhance Capabilities for Cost/Benefit Analyses
- Version 5.0B of EPRI's DYNATRAN software (1001988)—which models economic costs and benefits of network constraints and additions—was developed, providing new computational capabilities.
4. Conduct Workshop on Alternative Marketing Structures
- EPRI facilitated a 1-day workshop on November 7, 2001, to explore alternative power market structures for California. The workshop created a large public forum that featured two presentations on new research, three panel discussions with experts from throughout the state, and an audience of about 100 attendees representing a broad cross-section of industry interests.

Project Status:

This project is complete.

Program 34 Distributed Resources Information for Business Strategies

34.001: Strategic Intelligence on DER Market Developments

34.002: On-line Distributed Resources Web (DR-Web)

34.003: DER Educational Materials

Contract #: 500-00-023 **Project #:** 45

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$73,083

Match amount: \$187,717

Contractor Project Manager: Doug Herman (650) 855-1057

Commission Contract Manager: Jairam Gopal
(916) 654-4880

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of these three projects is to provide the Commission with information to enable California ratepayers and energy providers to realize the full potential of DER-based business strategies. EPRI involvement in DER research provides the unique access and intelligence necessary to identify new market niches, improve the use of generation and T&D assets, and evaluate DER-based solutions for commercial and industrial ratepayers and business opportunities for energy providers. These EPRI projects deliver information to support the planning and deployment of DER projects, analyze DER for retail business applications, understand the impacts of DER on utility distribution systems, and evaluate the integration, management, and control of DER technologies.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers;
- Improving the cost/value of California's electricity by supporting the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central-station power; and
- Improving the environmental and public health costs/risks of California's electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

1. Provide strategic intelligence on DER market trends and technology breakthroughs. One particular focus for 2002 is impact of high natural gas prices on the market for DER.
2. Host and update an on-line distributed resources web page that provides a comprehensive repository of DER-related information.
3. Develop and deliver DER educational materials that provide objective, science-based information on DER to educate customers, policy makers, and energy companies about the realities surrounding the use of DER technologies.

Actual Outcomes:

1. Strategic Intelligence on DER Market Developments
 - A technical report—*The Impact of Varying Natural Gas Prices on the Potential Distributed Resources Market* (1004464)—was published. The report describes a study of the DER market's response to changes in future gas prices in a range of plausible scenarios. This information

will energy planners to understand how factors like gas prices can impact the character as well as the scale of future DER markets.

- A technical report—*Assessment of a Transportable 200-kW Fuel Cell in Electric Cooperative Applications: Final Report: Georgia, Colorado, Alaska* (1007012)—was published. The report details a project cosponsored by EPRI and the National Rural Electric Cooperative Association (NRECA) Cooperative Research Network to demonstrate the use of transportable 200-kW phosphoric acid fuel cell power plants in rural distributed generation applications. The report describes more than three years of operation of the transportable fuel cell at three challenging sites: Jackson, Georgia, noted for its high temperature and humidity, Durango, Colorado, noted for its high altitude, and Anchorage, Alaska, noted for its cold winters.
- A newsletter—*Strategic Intelligence Update: DR Business Developments*—was published every six weeks on DER applications, business developments, partnerships, demonstrations, regulatory policy, and electrical interconnection and integration research.

2. Online Distributed Resources Web Page

- EPRI's DER program hosts and regularly updates DR-Web, an industry standard reference for comprehensive DER intelligence. DR-Web provides a comprehensive synthesis of EPRI's DER research, past and present, organized by subject matter: technology, business climate, application, environmental impact and permitting, electrical integration, and more.

3. DER Education Materials

- EPRI published a report, *A Primer on Distributed Energy Resources for Distribution Planning* (1004644), which provides utility distribution planners with essential information on DER technologies and issues involved in their application in distribution planning. The report will help distribution planners better evaluate DER technologies and make informed decisions about the use of DER as a substitute for, or a complement to, traditional distribution system capital improvements. The primer focuses on distributed generation technologies with a capacity of 500 kW to 5 MW as well as energy storage systems with capacities up to 15 MW and ride-through times as high as several hours.
- EPRI published a report, *Integrating Distributed Generation Into the Electric Distribution System* (1004633), which explains the rationale behind utility interconnection standards, and thus hopes to promote safe, quick and reliable interconnection. General guidelines and recommendations are provided to assure successful electrical integration of a distributed resource.

Project Status:

All projects are complete.

Program 35 - Overhead Transmission: Overhead Transmission Line Reference Manual

Contract #: 500-00-023 **Project #:** 46

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$21,538

Match amount: \$247,683

Contractor Project Manager: Raymond Lings (650) 855-2177

Commission Contract Manager: Jamie Patterson (916) 657-4819

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to revise EPRI's "Red Book"—the *Transmission Line Reference Book: 345 kV and Above*. The revision will update the handbook to incorporate the latest operating experiences and technologies, and to ensure that the handbook reflects both domestic and international operating practices and work environments. The revision will add new chapters as appropriate.

The *Transmission Line Reference Book: 345 kV and Above* is recognized worldwide as the leading handbook—the industry standard—on transmission line design. The printed book has a red cover, and has become widely known as the "Red Book" in the industry. The first edition was published in 1975, the second edition in 1982, and the second revised edition in 1987. It has not been revised since then.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through updating of the premier guide to transmission line design.

Proposed Outcomes:

1. Rewrite and update the book as necessary to incorporate the latest operating experiences and technologies, and to ensure that the handbook reflects both domestic and international operating practices and work environments.

Actual Outcomes:

- The actual re-write of chapters has started. 40% of the book was re-written in 2002 and the rest will be rewritten in 2003.
- In August 2002, the various team members met to review progress and to debate face-to-face the structure of various chapters. An advanced draft of the chapter on Electromagnetics was presented, along with a number of "applets"—small software routines designed to demonstrate

concepts within the book. Chapter outlines covering Lightning, Live Working, Radio Noise, Audible Noise, Corona Fundamentals and Corona Loss were presented and debated.

- The editorial panel was formed and met in August.
- A report was published entitled *Updating the EPRI Transmission Line Reference Book (Red Book)—2002 Progress Report* (1001762), which summarizes progress to date.
- Additional contracts will be placed for work to start in early January 2003.
- In January 2003, a review meeting will be held. At that meeting, draft chapters will be presented on Lightning Performance, Corona Phenomena, Radio Noise, and Audible Noise.

Project Status:

An Interim Report was published in late 2002. Commission participation in this project is complete.

EPRI Program 33 Emerging Distributed Resource Technologies

Contract #: 500-00-023 **Project #:** 40-43

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$379,927

Match amount: \$1,382,994

Contractor Project Manager: Doug Herman (650) 855-1057

Commission Contract Manager: Jairam Gopal
(916) 654-4880

Commission Contract Manager: Gary Klein (916) 653-8555

Fundamental Information about Distributed Energy Resources

33.001: DER Technology Assessments

33.002: Strategic Intelligence on Emerging DER Technology

33.003: DER Technology Business Venture Forum

Engines and Turbines for Grid Support

33.004: Technology Development Watch and Data: Engines and Small Gas Turbines

33.005 Monitoring and Validation of Field Applications: Engines and Small Gas Turbines

33.006: Business Case for DER Grid Support

Microturbines and Mini-Energy Storage

33.010: Validated Performance/Durability Data on Microturbine and Mini-Storage Products

33.011: Annual Microturbine and Mini-Storage Technology and Vendor Assessment

33.012: Integrated Microgeneration and Storage Concepts

Fuel Cells

33.013: Solid Oxide Fuel Cell R&D—Hybrid, Cogeneration, and Low-Temperature Systems

33.014: Residential Power Generator Technical Evaluation

33.015: Stationary Fuel Cell System Derived from Automotive R&D

33.016: Molten Carbonate Fuel Cell Systems: Technology Update

Project Description: The purpose of this project is to promote the potential that distributed energy resources (DER) have to provide a substantial portion of the energy alternatives now demanded by California electricity users. Both energy service providers and customers need accurate and unbiased information on the benefits and liabilities associated with commercially available and emerging distributed resource technologies. DER technologies offer third-party energy service providers and energy customers innovative solutions to their energy service needs. EPRI's Emerging DER Technologies program provides detailed information on commercially mature reciprocating engines and gas turbines, and emerging microturbines and fuel cell systems technologies. To gather this information, EPRI assesses advanced DER components, performs technology validations, and leads pre-commercial development of technologies that offer high pay-off. As a member, the Energy Commission obtains intelligence in three distinct areas: rapid changes in technology, development of new distributed resources, and post-R&D commercialization initiatives. This program examines a balanced portfolio of near, intermediate, and long-term options.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers;
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power; and
- Improving the environmental and public health costs/risks of California's electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

- Perform DER technology assessments including current status, potential for improvements, critical components and issues, and the likelihood of success.
- Deliver unbiased accurate strategic intelligence on emerging

DER technologies to increase customer choice and enable competition.

- Organize and conduct a DER technology business venture forum to allow participants to learn about new technology developments and market trends.
- Demonstrate a novel control and dispatching hardware/software system for distributed generation.
- Track and review current developments in microturbine and mini-energy storage technologies and vendors.
- Perform independent assessments that evaluate vendor claims.
- Explore and evaluate promising new concepts for integrating microgeneration and energy storage.
- Evaluate the technical and business potential of emerging next-generation solid-oxide fuel cell technologies, including hybrid, cogeneration, and low-temperature systems.
- Test the capabilities of small power systems for residential use.
- Exploit fuel cell developments in automotive markets for high-value commercial and small industrial stationary DR applications.
- Follow and develop information from field tests of molten carbonate fuel cells being conducted around the United States and overseas.

Actual Outcomes:

1. DER Technology Assessments

- A technical report—*Performance Testing of a Flywheel-Based Uninterruptible Power Supply* (1004444)—was published that provides complete details of performance testing of the UPS system, including test instrumentation and setup, test results, and overall conclusions. The system offers an innovative power quality solution for a broad range of industrial and commercial applications. It provides stored energy, immediately available, to protect critical loads against temporary power disturbances such as outages, sags, and surges.
- A technical report—*Stirling Engine Assessment* (1007317)—was published that presents a summary of the technical trends, commercialization status, and economic viability of Stirling engine technology for distributed generation applications. While fuel cells and microturbines have received a majority of the recent focus, Stirling engine technology is beginning to receive more attention as a viable, and potentially competitive, distributed generation option.

2. Strategic Intelligence on Emerging DER Technology

- Six issues of an informative intelligence report—*Strategic Intelligence Update: Technology Development*—were published, providing up-to-date news and expert analysis

of emerging DER technologies and trends—both domestic and internal.

3. DER Technology Business Venture Forum

- A high-level professional conference on venture capital financing of emerging energy technology firms, specifically those related to distributed resources, was held in July 2002 in Boston. It provided a forum for utilities, energy companies, equipment manufacturers, and vendors to discuss the latest technology, market, and policy developments. A report—*Report on the EPRI Business Venture Forum 2002: Whither Capital Markets for DR?* (1004445)—was published that summarizes and characterizes presentations made at the forum.

4. Control and Dispatching Software/Hardware

- The project team installed a control and dispatching system for distributed generation at the Lovelace Medical Center in Albuquerque, New Mexico and documented the system's operation. A technical report, *Novel Distributed Generation Control and Dispatching System: Application Validation and Benefits Quantification* (1004448), describes the system, which allows the connection of multiple generators at a number of sites to a utility control and monitoring system for the purpose of providing peaking power for the utility. Using distributed generation for this purpose is a potentially cost-effective solution to localized power system constraints caused by the inability to increase power transmission into an area experiencing steady growth in local power demand.

5. Microturbine and Mini-Storage Technology and Vendor Assessment

- The project team developed a technical review report, *Microturbine and Mini-Storage Technology and Vendor Assessment—Annual Update* (1004454), which includes vendor profiles and product timing information, as well as technology performance, application, and operating characteristics.

6. Integrated Microgeneration and Storage Concepts

- The project team conducted engineering design, cost, and test analysis research on existing technology concepts for integrating microgeneration and energy storage. A web-based report, *Integrated Distributed Generation and Energy Storage Concepts* (1004455), was produced that describes the performance benefits of combining microturbines and other distributed generators with various energy storage concepts.

7. Solid Oxide Fuel Cell (SOFC) R&D—Hybrid, Cogeneration, and Low-Temperature Systems

- To help guide future R&D investments in fuel cell hybrids, EPRI undertook a study with DOE to investigate the future market potential for fuel cell hybrids in the United States. The study's main goal was to evaluate the scale, efficiency,

and performance relationships of fuel cell hybrids to satisfy market needs and to quantify the market potential under a competitive electricity market scenario. A report, *Fuel Cell Hybrids: Market Assessment and Early Adopter Study* (1007096), presents the study results, which will be useful in shaping future product requirements and establishing research and development goals.

- A technical update report, *SOFC Technology Development* (1004457) was published that describes development and test results as well as technological and economic assessments of emerging SOFC applications, including hybrid SOFC-combustion turbines, SOFC-based cogeneration, and low-temperature planar SOFCs.
 - A technical report—*1 MW Fuel Cell Project: Test and Evaluation of Five 200 kW Phosphoric Acid Fuel Cell Units Configured as a 1 MW Power Plant* (1007014)—was published that describes a demonstration of the new technology that is needed for utility management and control of multiple fuel cell power plants at a single location in an assured power application.
 - The project team continued 2001 work to evaluate polymer electrolyte membrane residential power generators and to define and test SOFC systems for residential power. Findings—including performance, cost, and durability information—are presented in a web-based technical review document, *Residential Power Generation Technical Evaluation* (1004457).
8. Stationary Fuel Cell System Derived from Automotive R&D
- Researchers gathered information on performance, cost, and durability, which will be presented in a technical report, *Stationary Fuel Cell System Derived from Automotive R&D* (1004458), scheduled for publication in March 2003.
9. Molten Carbonate Fuel Cell Systems: Technology Update
- The project team followed a series of MCFC field tests conducted in the United States and overseas and developed information on current activities, as well as durability, performance, interconnectivity, and related issues. Findings are presented in a technical review publication, *Molten Carbonate Fuel Cell Systems Technology Update* (1004459), scheduled for publication in March 2003.

Project Status:

The projects in this program are complete.

Program 40 Grid Planning and Development

40.002: Power System Analysis Package for Transmission Planning

40.004: Risk-Based Transmission Expansion Planning Tool

Contract #: 500-00-023 **Project #:** 50

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$77,000

Match amount: \$92,502

Contractor Project Manager: Stephen Lee (650) 855-2486

Commission Contract Manager: Don Kondoleon
(916) 654-3918

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: This project is developing new tools and information that could be used to improve the reliability and efficiency of the electricity power grid in California and the western region. These EPRI products enable California power system operators to cost-effectively upgrade systems, merge databases from different sources, exchange information in real time, and better manage systems during and following emergencies. One key product is the extension of the Common Information Model (CIM), now gaining widespread use in control centers. Using real-time CIM data off-line will improve the accuracy of planning results, increase cooperation between planners and operators, and improve productivity. To improve several of the most valuable industry standard tools, the EPRI Grid Planning and Development program is also upgrading EPRI's Power System Analysis Package to integrate with the CIM, and improving the transmission reliability software (TRELSS). These tools allow planners to quickly identify power system limitations and recommend mitigation while balancing cost and reliability.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies that help balance the competing needs of maximizing the use of the grid while maintaining the security of the system; and
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Enhance the Power System Analysis Package for Transmission Planning (PSAPAC) by providing a full graphical user interface for the Small Signal Stability Program and interfaces to the CIM database. PSAPAC is a comprehensive suite of advanced computer programs capable of analyzing all aspects of steady state and dynamic power system performance.
2. Improve the Risk-Based Transmission Expansion Planning Tool (TRELSS) by updating its computational techniques,

graphic user interface, database management, and use of object-oriented software technology.

Actual Outcomes:

1. Power System Analysis Package for Transmission Planning (PSAPAC) Enhancements
 - The Small Signal Stability Program (SSSP) Version 6.0 with graphical user interface and interfaces to the CIM database was developed and delivered with a companion manual (EPRI product 1001625).
 - Probabilistic Load Flow (PLF) beta version was developed and delivered.
2. Risk-Based Transmission Expansion Planning Tool (TRELSS)
 - TRELSS Version 6.0 was developed and delivered as EPRI product 1001629. TRELSS is an essential product in today's environment due to the security and reliability issues that have been raised as a result of deregulation. TRELSS is a package that uses enumeration of generation and transmission contingencies to evaluate power network reliability.
 - A Technical Report, *Transmission Planning Under Open Access* (1001630), was published. The report presents a brief description of the transmission planning practices under the old paradigm, an analysis of the impact of deregulation in the electrical power sector on transmission planning methods, and surveys of existing planning practices in Norway, the United States, and Argentina. The report then describes in detail an innovative transmission system planning methodology adapted to a liberalized energy market. The full system includes a mathematical formulation of new market rules, methods of identifying and managing congestion problems, and an approach to making investment decision under uncertainty.

Project Status:

These two projects are now complete.

Program 86 Enterprise Information Security (EIS)

Contract #: 500-00-023 **Project #:** 52

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$45,000

Match amount: \$1,421,096

Contractor Project Manager: Jim Fortune (650) 855-2500

Commission Contract Manager: Laurie ten Hope
(916) 654-5045

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to address concerns over the security of the energy industry's electronic infrastructure against cyber threats. These threats range from corporate espionage by competitive rivals to sabotage by hackers or terrorists. Immediate concerns center on the vulnerabilities of electronic operations systems such as supervisory control and data acquisition (SCADA) and plant distributed control systems (DCS) and their interconnectivity with corporate business systems. As the energy industry becomes increasingly automated and electronically connected, a concerted cyber attack could be catastrophic from business, customer and national security perspectives.

This EPRI program identifies and addresses security issues through a series of meetings and workshops that provide forums for sharing information on best practices, lessons learned, and vulnerability assessment results. In addition, the program focuses on the development, application, and testing of technical solutions.

This project supports the PIER goal of:

- Improving the reliability of California's electricity by leveraging the collective knowledge of the participants to develop strategies for protecting the State's critical electric power infrastructure against cyber threats.

Proposed Outcomes:

1. Organize and facilitate workshops for collaborative exchange of information and ideas to support the development of robust security programs.
2. Provide security guidelines covering critical security activities and policies and procedures, all reflecting the collective knowledge of the industry.
3. Provide security enhancements that reduce the vulnerability of control centers, SCADA systems, power plant controls, field devices, customer electronic meters, and the protocols used to communicate with these devices, while meeting operational needs.
4. Enhance the risk assessment framework developed in 2001 to help decision makers understand and evaluate the costs and benefits of different security measures.

Actual Outcomes:

1. Workshops
 - Three topical workshops were delivered in 2002.
2. Guidelines, Policies and Procedures:
 - EPRI published a report, *Security Vulnerability Self-Assessment Guidelines for the Electric Power Industry* (1001639), that provides detailed guidelines and technical information that will assist any organization engaged in generating, transmitting, distributing, or marketing

electric power in performing its own security self-assessment.

3. Security Enhancements

- EPRI published a report, *ICCP (TASE.2) Security Enhancements: Executive Summary* (1001641) that summarizes the current security enhancements that EPRI is recommending to secure the ICCP. The detailed recommendations are presented in EPRI report 1001642.
- A technical report, *ICCP (TASE.2) Security Enhancements: Volume 1* (1001642), was published that details the security requirements for the Inter-Control Center Communications Protocol (ICCP-IEC60870-6 TASE.2), also known as TASE.2. Based on these requirements, the report assesses the current ICCP for potential vulnerabilities and recommends solutions.
- A technical update report, *Security Enhancements for Utility Information Architectures* (1002651) was published. It presents the results of a study conducted to assess the impact on performance of the security measures being proposed for the common protocols used for digital control of power system equipment, and to determine what additional security measures outside the domain of protocols may be needed for complete end-to-end security.

4. Risk Assessment Framework

- A web-accessible risk assessment framework was completed in 2002.

Project status:

All projects under this program are complete.

Program 94: Energy Storage for Transmission & Distribution Applications

94.002 Field Trials of Promising Prototype And/Or Emerging Energy Storage Options for T&D Applications

Contract #: 500-00-023

Contractor: EPRI

Contract Amount: \$31,111

Match Amount: \$28,106

Contractor Project Manager: Steven Eckroad, (650) 855-1066

Commission Project Manager: Laurie ten Hope

(916) 654-5045

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to demonstrate promising new energy storage options designed specifically for transmission and distribution (T&D) reliability, peak shaving, and VAR control applications. The project will select final design parameters, perform cost/benefit studies,

assist in building unit(s), install independent performance monitoring equipment, analyze operating data, and conduct long-term reliability and operational analyses.

This project supports the PIER Program objectives of:

- Improving the reliability/quality and the energy cost/value of California's electricity through innovative energy storage technologies that help increase grid utilization while maintaining system stability.

Proposed Outcomes:

Reduce capital costs and maximize T&D equipment use factors by deploying energy storage equipment based on credible cost and performance data from field trial demonstrations of candidate energy storage options.

Project Status:

In fall 2002 EPRI and AEP signed a tailored collaboration agreement to demonstrate a 100 kW (500 kW power quality), 750 kWh peak shaving sodium sulfur (NaS) battery. This battery has been successfully installed at an AEP office building near Columbus, Ohio. A two-year test program is planned. A web-based interim technical report describing plant design and expected performance will be delivered in March 2003. This phase of the project is complete.

Target 18.3 Airport Solutions

Contract #: 500-00-023

Contractor: EPRI

Subcontractors: Jorge Emmanuel DBA; Jamie Knapp DBA; Bettie J. Davis DBA; Brian Hirt; National Electric Energy Testing Research & Applications Center (NEETRAC).

Contract Amount: 2001: \$23,749

Match Funding: 2001: \$199,700

Contractor Project Manager: Andra Michel (650) 855-2101

Commission Project Manager: McKinley Addy

(916) 657-0833

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to evaluate and develop new environmental and energy technologies, and to apply existing technologies—such as electric vehicles—to airport infrastructure to reduce pollution and subsequent costs. Aviation is a key sector of California's economy, with important consumer, energy, and air quality impacts. California's largest airports contribute hundred of millions dollars every year to local and regional economies. However, airports face challenges, including the need to reduce pollutant emissions and control operating costs.

Converting ground transportation and other airport equipment

to electricity is one solution to these issues. The electrification of airport gates and the use of electric ground support equipment (GSE) and alternative fuel vehicles have been identified as effective emission reduction compliance measures. These measures promote the public good of cleaner air. Additionally, the use of electric GSE offers energy efficiency and operating cost reduction benefits to airports and California's consumers. These benefits foster the achievement of high-priority public policy goals.

However, the increased use of high and variable frequency electric GSE at airports could adversely affect the quality and reliability of airport electric power systems. As a result, the potential impact of electric GSE and other electrification on power system quality must be understood if California airports are to comply with air quality requirements without compromising airport power quality. EPRI's Airport Solutions Target has developed the necessary methodologies and models to assess the feasibility of electrification and the associated economic, environmental, and power quality impacts on an airport-specific basis.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing information on efficiency improvements available for use by airports; and
- Improving the environmental and public health costs/risks of California's electricity by reducing emissions from the internal combustion engines used by airport facilities by replacing them with electrically-powered equipment.

Proposed Outcomes:

1. Provide key technical and economic information on electrification of GSE and other airport equipment and use of alternative fuel vehicles—including information on new technology development, environmental impacts, power quality issues, application planning and experience, and market penetration.
2. Conduct a Tailored Collaboration entitled Power Quality Impacts of Airport GSE Charging Systems (TC-51441-001-28325). This project will study the existing GSE charging systems at five airports (including four in California) to document the power quality characteristics of the systems and assess their impacts on the primary and secondary electric distribution systems that supply power to the airports and gate areas.

Actual Outcomes:

Technical and Economic Information

1. EPRI organized a national Electric GSE Market Penetration Issues Round Table Meeting in Washington, DC. The meeting

was designed to bring together representatives from airports, airlines, vehicle and component manufacturers, government agencies, standards-making bodies, and utilities to address key issues. The meeting, which was scheduled for September 12, 2001, was cancelled due to the terrorist attacks. However, the nine presentations scheduled to be delivered at the meeting were compiled in a proceedings titled *EPRI Electric GSE Market Penetration Issues Round Table Proceedings: September 2001* (1006002) and delivered to all members. The presentations contain vital information on new technology development, application experience, and power quality issues. A conference call, led by Robert Graham, was open to all Electric GSE Market penetration issues round table meeting members followed the proceedings.

2. A fact sheet—*American Airlines Installs Fast Charging at DFW Airport* (1006011)—was published on one airline's experience with fast charging technology for GSE electrification.
3. EPRI hosted two national workshops of the Electric Bus User Group. These workshops were held on April 16-17, 2001 in Tempe, AZ, and on October 9-10, 2001 in Denver, CO. The events offered participants information on new technologies, energy storage and charging issues, and application experience. The proceedings, titled *Electric Bus Users Group Workshop Proceedings: April 2001* (1006158) and *Electric Bus Users Group Workshop: Proceedings: October 2001*, (1006643), were published.
4. A conference call meeting of the Airport Solutions Target Funders was held on November 19, 2001. Minutes of the meeting are available.

Project Status:

This project is complete.

Target 34 Distributed Resources: Information for Business Strategies; 34.1 Using Distributed Resources to Create Retail Strategic Advantage; 34.2 Integration of Distributed Resources on Electric Distribution Systems; 34.3 Using Distributed Resources to Create Electric Distribution System Strategic Advantage; 34.4 Market Research and Tools for Retail Energy Services

Contract #: 500-00-023

Contractor: EPRI

Subcontractors: Arthur D. Little Inc., EPRI Solutions, Resource Dynamics Corporation

Contract Amount: 2001: \$271,524

Match Funding: 2001: \$2,941,409

Contractor Project Manager: Dan Rastler (650) 855-2521

Commission Project Manager: Jairam Gopal (916) 654-4880
Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to provide the Commission with information and tools to enable California ratepayers and energy providers to realize the full potential of DR-based business strategies. EPRI involvement in DR research provides the unique access and intelligence necessary to identify new markets niches, improve the use of generation and T&D assets, and evaluate DR-based solutions for commercial and industrial ratepayers and business opportunities for energy providers. The target focuses on creating integrated, dependable, packaged solutions and providing information to better understand the DR market, both locally and globally. This EPRI target provides information to support the planning and deployment of DR projects, analyze DR for retail business applications, understand the impacts of DR on utility distribution systems, and evaluate the integration, management, and control of DR technologies.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers;
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power; and
- Improving the environmental and public health costs/risks of California's electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

1. Provide strategic information on the DR business environment, trends, technologies, customers, and markets.
2. Compile detailed information to allow analysis of DR for retail business applications.
3. Provide information to assist distribution planners in integrating DR in utility electric distribution systems.
4. Supply information, methodology, and tools to support analysis of DR impacts on electric distribution systems.
5. Conduct market research and provide information on DR markets.
6. Conduct a Tailored Collaboration entitled "Tests and Evaluation of Four Newly Commercialized Distributed Generators in San Diego, CA."
7. Conduct a Tailored Collaboration entitled "Distributed Energy Resources Public Web."

Actual Outcomes:

1. Strategic Information
 - A quarterly newsletter—*Strategic Intelligence Update: DR Business Developments*—was published on DR applications, business developments, partnerships, demonstrations, regulatory policy, and electrical interconnection and integration research.
 - An online version of *EPRI Distributed Resources Technical Assessment Guide* (DR-TAG) was made available. The web-based Guide includes information on product configurations, technology status, development issues, and prospects for future improvements.
 - Educational tech briefs were published on key DR topics.
 - The 2nd Annual Business Venture Forum, an annual national workshop, was held July 25-26 in San Francisco. It provided a forum for utilities, energy companies, equipment manufacturers, and vendors to discuss the latest technology, market, and policy developments.
 - Advisory Group Meetings were held in February, July, and October.
2. Retail Business Strategies
 - A report—*Managing Price Risk with Distributed Resources* (1003972)—was published on the potential value of DR as a hedging device for end-use customers.
 - A report—*Framework for Evaluating DR Business Cases* (1003971)—was published on a decision-making framework for analyzing DR-based business opportunities in the context of a retail portfolio, or as a business unit targeting a defined set of customers with identified needs.
3. Integration of DR in Distribution Systems
 - A report—*Technical Assessment and Evaluation of DR Micro-Grids* (1003973)—was published on the technical and economic feasibility of designing and operating micro-grids.
 - A software tool—*Distributed Resources Integration Assistant: Version 1.0* (1006540)—was developed to provide useful engineering information, calculators, and screening tools to assist those involved with properly integrating DR into the electric power system.
4. DR Impacts on Distribution Systems
 - A report—*DR Cost Impacts on Transmission and Distribution Systems* (1003975)—was published to assess the economic pros and cons of employing DR technologies when T&D system upgrades are needed.
 - A report—*Siting of DR Units: Process and Issues* (1003974)—was published on the issues and principles involved in the DR siting process and outlines how most tasks can be conducted.
5. Market Research
 - A report—*Market Research in Residential DR Technologies* (1003976)—was published on results of

primary research into issues facing DR in residential markets with a special emphasis on California markets as leaders in accommodating their behaviors to volatile energy markets.

- A report—*DR Adoption Experience in the Commercial Sector* (1003977)—was published on commercial businesses' experience in using DR technologies and the extent to which these technologies met the economic and operations experience of these early adopters.
6. Tailored Collaboration—Evaluation of Five Distributed Generators
- A demonstration project was conducted, siting new DER products at end-user facilities with the purpose of collecting end-user experiences and better understanding the steps required to site DER devices. A full complement of performance, emission, power quality, and noise tests were also conducted.
7. Tailored Collaboration—DER Public Web
- A website containing nearly all the information generated by the EPRI DR targets in the last three years was made available in a well-organized, easy-to-use structure.

Project Status:

This project is complete.

Target 38A Flexible AC Transmission System (FACTS)—Convertible Static Compensator

Contract #: 500-00-023

Contractor: EPRI

Subcontractors: Siemens Power Transmission & Distribution

Contract Amount: 2001: \$62,500

Match Funding: 2001: \$274,237

Contractor Project Manager: Aty Edris (650) 855-2311

Commission Project Manager: Don Kondoleon (916) 654-3918

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to demonstrate an advanced controller technology with the potential—if it were applied—to substantially increase power transfer capability on the transmission grid in California and the western region. The Convertible Static Compensator (CSC) is the latest FACTS (Flexible Alternating Current Transmission System) Controller developed under EPRI's FACTS technology development and application program. The CSC is an innovative power electronics-based controller that provides multiple compensating modes, which are needed to securely increase power transfer capability limits of existing transmission systems. The Controller provides flexible dynamic voltage control (to avoid voltage instability), as well as simultaneous

real and reactive power flow control on multiple transmission corridors (without risk of transient or dynamic instability). The CSC offers this flexibility by allowing its converters to be connected in shunt, in series, in shunt/series, or in series/series with two lines.

This EPRI project supports demonstration of the world's first CSC—two 100-MVA Voltage Source Converters—which has been installed and is in operation at New York Power Authority's (NYPA's) Marcy Substation in Utica, New York. The CSC is enabling NYPA to mine 240 more MW of power from the grid precisely when they need it most—during contingency situations. Membership in this project provides the Energy Commission with key technical information on installation and operation of the CSC, and integration of the CSC in a power grid.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system.
- Improving the safety/security of California's electricity system by developing technologies to maintain and enhance system security in the face of increasing traffic and congestion, while avoiding the environmental impacts associated with new transmission lines and corridors.

Proposed Outcomes:

1. Install CSC voltage source converters for shunt and series compensation.
2. Conduct initial field tests.

Actual Outcomes:

- Phase 1 of the project (Static Synchronous Compensator [STATCOM] operation) was successfully commissioned in June this year.
- CSC in the shunt operation modes (+/-200 Mvar STATCOM) is now in service, and is being monitored for fine-tuning the control and protection system.
- A dedication ceremony was held June 21 to mark the startup of the first phase of the CSC.
- A technical progress report *Convertible Static Compensator (CSC) for New York Power Authority*, EPRI no. 1001970, was published.
- A review of the CSC operation was presented at the FACTS Users Group Meeting on October 18-19, 2001 in New York City.

Project Status:

This project is complete.

Target 39 Grid Operations & Management

Contract #: 500-00-023

Contractor: EPRI

Subcontractors: ABB Power T&D Co., Inc.; Best Systems, Inc.; Bonneville Power Administration (BPA); Decision Systems International; Hoffman Publications, Inc.; Incremental Systems; Iowa State University; Michael Terbruggen, dba; Quality Training Systems, Inc.; Xtensible Solutions, Inc.

Contract Amount: 2001: \$201,923

Match Funding: 2001: \$5,156,709

Contractor Project Manager: Stephen Lee (650) 855-2486

Commission Project Manager: Don Kondoleon
(916) 654-3918

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to support EPRI's collaborative program in Grid Operations and Management, which is developing new tools and information that could be used to more efficiently and reliably operate the electricity power grid in California and the western region. EPRI products enable power system operators to cost-effectively upgrade systems, merge databases from different sources, exchange information in real time, and better manage systems during and following emergencies. To ensure the grid is capable of supporting the competitive market, EPRI software also offers capabilities for more accurately estimating and monitoring power system transactions. In addition, as the number and scale of transactions on the California grid increase, and as system security is challenged, EPRI provides new information and approaches for ensuring the reliability of the system.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system; and
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Provide software and information to reduce the costs and improve the efficiency of control center operation.
2. Provide software, methods, and information to enhance the transaction without impact on security.
3. Provide new methods and information to improve the

security of the system and avoid management capabilities of transmission system operations, and to allow increased transactions system failures.

Actual Outcomes:

1. Reduce the Costs and Improve the Efficiency of Control Center Operations
 - Three sets of tests were conducted that demonstrated a common language for information sharing among utility applications. In the tests software vendors exchanged versions of the Common Information Model (CIM) translated into the industry standard eXtensible Markup Language (XML), which permits the exchange of power system models in a format that any Energy Management System can understand using Internet or Microsoft technology.
 - A proposal was developed for a CIM standard, which would permit assembling diverse sources of enterprise data into a common database.
 - Two reports were produced on changes necessary to the existing standard for the real-time standard for data exchange.
 - Version 2.0 of EPRI's GOP Graphics System was developed and tested. The software, which provides a standard Graphical User Interface (GUI) for any EPRI grid operations software, was upgraded to allow remote access to applications.
 - Two products were developed to educate operators in emergency system management and restoration: the Tutorial for System Restoration and Version 2.0 of the Operator Training Simulator (OTS).
 - *Instructor Guidelines for Use of an Operator Training Simulator* was published.
 - A tri-annual newsletter was published on new software programs and methods for improved transmission grid operation.
2. Enhance Transaction Management
 - Two reports were published on design specifications for a Topology Estimator and a beta version of Topology Estimator software was developed. This product will enable accurate estimate of the real-time network topology status, which is crucial for correct scheduling of generations and transactions.
 - EPRI participated in industry collaborative efforts to develop electronic scheduling capabilities, including Version 1.4 of the transaction management software Open Access Same-time Information System (OASIS) software.
3. Improve System Security
 - A report was published that summarizes the 15 major accomplishments of EPRI's Security Mapping and Reliability Index Evaluation (SMRIE) project, which

provides system operators with the capacity to monitor security levels quickly and accurately.

- A report was published that describes on-line capabilities for detecting high-risk, or N-k, contingencies that result in unscheduled outages of multiple components within bulk high-voltage electric transmission systems.
- A report was published that provides a systematic procedure for determining the effects on an entire power network of hidden failures in protection systems.

Project Status:

This project is complete.

Target 40 Grid Planning & Development

Contract #: 500-00-023

Contractor: EPRI

Subcontractors: Best Systems, Inc.; Decision Systems International; EDF—Electricite de France; EPRI Solutions; P Plus Corp.; Southern Company Services, Inc.; Vanessa MacLaren-Wray, dba

Contract Amount: 2001: \$98,077

Match Funding: 2001: \$4,282,593

Contractor Project Manager: Stephen Lee (650) 855-2486

Commission Project Manager: Don Kondoleon (916) 654-3918

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to increase the speed and efficiency of planning tools. Grid planning cycles today in California and throughout North America are continually being compressed. To make effective decisions under these conditions, power system planners need tools that allow them to rapidly obtain and process information, solve complex problems, and, in some cases, provide a sound business justification for their decisions. In addition, planners must often seek to maximize the value of their power grid assets while at the same time maintaining system reliability.

EPRI products in this area are designed to meet new grid planning needs in California and elsewhere by increasing the speed and efficiency of planning tools. For example, one product will help planners take advantage of advances in grid operations tools by improving capabilities for sharing real-time data with grid operations applications. Other products are increasing capabilities of existing software for simulation and analysis of grid conditions. EPRI is also strengthening capabilities for evaluation of grid security and providing new tools for conducting cost/benefit studies. The one-day workshop sponsored by this target in association with the Energy Commission provided a large public forum for

evaluation of alternative wholesale market structures for California.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system and
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Develop and upgrade grid planning software and methods to increase the speed and efficiency of their analytical capabilities and improve their ease of use.
2. Enhance grid planning software used for assessing transmission system reliability.
3. Improve grid planning software with capabilities for cost/benefit analyses of network additions and constraints.
4. Conduct a cofunded project entitled "Workshop on Exploring Alternative Wholesale Market Structures for California."

Actual Outcomes:

1. Improve Software Efficiency and Ease of Use
 - Two mainline planning applications—IPFLOW and DYNAMICS—were integrated with a database compliant with the Common Information Model (CIM), enabling these planning applications to utilize real-time operating data and share data with operators.
 - New computational techniques to increase analysis speed were developed for a restructured version of the Electromagnetic Transients Program (EMTP), a software widely used for simulating and identifying solutions for high-speed transients. *Restructured Electromagnetic Transients Program; Progress Report: (EMTP-RV) (1001989).*
 - Object-oriented technology was applied to the Power Systems Analysis Package (PSAPAC) software, which will increase the processing efficiency and substantially reduce the cost of development.
 - Version 6.0, incorporating an improved graphical user interface, was developed for the Interactive Power Flow (IPFLOW) program, which supports a family of planning applications, including ETMSP, VSTAB, and SSSP.
 - Version 2.0 of EPRI's GOP Graphics System was

developed, providing a standard graphical user interface for all EPRI grid planning applications.

- Software support was provided to users of EPRI's grid planning and development software, including ongoing distribution and maintenance, user group support, and software enhancements.
 - A triannual newsletter was published on new software programs and methods for improved transmission grid planning.
2. Strengthen Capabilities for Reliability Assessment
- A report —*Restructured Transmission Reliability Evaluation for Large-Scale Systems (TM) (TRELSS (TM)): An Implementation Plan* (1001987) - was published on progress in upgrading EPRI's Transmission Reliability Evaluation for Large-Scale Systems (TRELSS)—commonly used for assessing reliability of bulk power systems—to update its computational techniques, GUI, database management, and use of object-oriented technology.
 - A report - *Modeling and Diagnosis Methods for Large-Scale Complex Networks: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report* (1006092) – was published that presents progress on modeling and diagnosis methods for large-scale complex networks.
 - A report - *Intelligent Management of the Power Grid: An Anticipatory, Multi-Agent, High Performance Computing Approach: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report* (1006091) – was published that describes the progress made in understanding the grid as a customer-driven, anticipatory system.
 - A report - *Minimizing Failures While Maintaining Efficiency of Complex Interactive Networks and Systems: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report* (1006093) - was published that discusses minimizing failures while maintaining efficiency of complex interactive networks and systems.
 - A report - *Context-Dependent Network Agents: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report* (1006094) - was published that presents progress on developing and demonstrating "context-dependent network agent" (CDNA) technology.
 - A report - *From Power Laws to Power Grids: A Mathematical and Computational Foundation for Complex Interactive Networks: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report* (1006095) – was published that focuses on understanding the behavior of large-scale complex interactive networks and investigating their mathematical underpinnings.
3. Enhance Capabilities for Cost/Benefit Analyses

- Version 5.0B of EPRI's DYNATRAN software (1001988)—which models economic costs and benefits of network constraints and additions—was developed, providing new computational capabilities.

4. Conduct Workshop on Alternative Marketing Structures

- EPRI facilitated a 1-day workshop on November 7, 2001, to explore alternative power market structures for California. The workshop created a large public forum that featured two presentations on new research, three panel discussions with experts from throughout the state, and an audience of about 100 attendees representing a broad cross-section of industry interests.

Project Status:

This project is complete.

Target 33 Emerging Distributed Resource Technologies; 33.1 Advanced Engine Products and DR Applications; 33.2 Small Gas Turbines (1-10 MW) for Distributed Power Markets; 33.3 Microturbine Products and Assessments; 33.4 Fuel Cell Distributed Power Systems; 33.5 Fuel Cell Energy Storage Systems Derived from Automotive Fuel Cell R&D Programs; 33.6 Interconnection Hardware Assessment and Development

Contract #: 100-98-001

Contractor: EPRI

Subcontractors: Gas Research Institute, Nexant Inc., Energy International Inc., ADI Thermal Power Corporation, American Electric Power Co. Inc., Powerco Us. Inc., Arthur D. Little Inc., National Rural Electric Cooperative Association, Power Computing Solutions Inc., Rolls-Royce Inc., Southern California Edison Co., EPRI PEAC Corporation.

Contract Amount: 2001: \$461,251

Match Funding: 2001: \$3,782,757

Contractor Project Manager: Dan Rastler 650/855-2521

Commission Project Manager: Jairam Gopal 916/654-4880

Commission Contract Manager: Gary Klein 916/653-8555

Project Description: The purpose of this project is to promote the potential that distributed resources (DR) have to provide a substantial portion of the energy alternatives now demanded by California electricity users. Both energy service providers and customers need accurate and unbiased information on the benefits and liabilities associated with commercially available and emerging distributed resource technologies. DR technologies offer third-party energy service providers and energy customers innovative solutions to their energy service needs. EPRI's Emerging DR Technologies target provides detailed information on commercially mature

reciprocating engines and gas turbines, and emerging microturbines and fuel cell systems technologies. To gather this information, EPRI assesses advanced DR components, performs technology validations, and leads pre-commercial development of technologies that offer high pay-off. As a member, the Energy Commission will obtain intelligence in three distinct areas: rapid changes in technology, development of new distributed resources, and post-R&D commercialization initiatives. This target examines a balanced portfolio of near, intermediate, and long-term options.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California’s electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers;
- Improving the energy cost/value of California’s electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power; and
- Improving the environmental and public health costs/risks of California’s electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

1. Provide unbiased accurate information on emerging DR technologies to increase customer choice and enable competition.
2. Provide methods and guidelines for comparing and testing technologies to improve evaluation of emerging DR technologies.
3. Accelerate development and application of advanced engines for power generation and T&D support through monitoring of technology development and benchmarking of new products.
4. Support application of small gas turbine technology (1-10 MW) by documenting existing installations.
5. Accelerate the development of microturbine technologies by documenting the performance of current and emerging microturbines.
6. Bring to market readiness fuel cell technologies that include polymer electrolyte membrane (PEM) fuel cell systems and ultra-high efficient solid oxide fuel cells (SOFC).
7. Accelerate development of fuel cell energy storage systems through technology assessment and preliminary system design.
8. Ensure the efficient and safe application of distributed resources by compiling up-to-date information on interconnection hardware.

9. Conduct a Tailored Collaboration (TC) project entitled "Emissions Testing and Certification Guidelines for DG Generators."

Actual Outcomes:

1. Unbiased Information
 - A quarterly newsletter—*Strategic Intelligence Update: Technology Development*—was published on the latest breaking information on DR technology and research development.
 - An online version of *EPRI Distributed Resources Technical Assessment Guide (DR-TAG)* was made available to CEC staff. The web-based Guide includes information on product configurations, technology status, development issues, and prospects for future improvements.
 - A technical report—*Enhancing DR Value Through Heat Recovery (1003958)*— was published on heat recovery options that could improve the performance and efficiency of DR technology.
 - The 2nd Annual Business Venture Forum, an annual national workshop, was held July 25-26 in San Francisco. It provided a forum for utilities, energy companies, equipment manufacturers, and vendors to discuss the latest technology, market, and policy developments.
 - Advisory Group Meetings were held in February, July, and October.
2. Evaluation Guide
 - The *Guide for Test and Evaluation of DR Technology Performance (1003963)* was published, providing a uniform methodology and references for consistent evaluating and testing of emerging DR technologies.
3. Advanced Engines
 - A report—*Insights on Development of Advanced IC Engines (1003959)*—was published to report on state-of-the-art engine technology under development at manufacturers, U.S national laboratories, and universities. The report assesses engine R&D activities for their potential to improve engine performance and/or reduce emissions.
 - A report—*Performance Data: Benchmarking of New and Emerging Engine Products (1003960)*—was published on performance characteristics of leading engine products from every major reciprocating engine manufacturer.
 - A report—*Case Studies of IC Engines for T&D Support (1003961)*—was published on utility application experiences and lessons learned with engines and combustion turbines used for T&D support.
4. Small Gas Turbines (1-10 MW) for Distributed Power Markets
 - A report—*Case Studies of CTs for T&D Support (1003962)*—was published to document one utility’s

efforts to select, site, install, and operate a mobile combustion turbine at a rural substation.

5. Microturbines

- A report—*Performance and Electrical Characterization Tests on a Microturbine Commercial Prototype: Part III* (1003964)—was published to characterize operation of a grid parallel/grid independent commercial MTG.
- A report—*MTG Field Test Program* (1006394)—was published to ascertain the cost, performance, durability, reliability, and maintainability of various microturbines in an actual customer environment.
- A report—*Test and Evaluation of Two Microturbines at Customer Sites* (1006591)—was published to report the test results of two microturbines operating at customer sites. Also, to report the problems and other challenges encountered, along with customer viewpoints.

6. Fuel Cell Distributed Power Systems

- A report—*Assessment of SOFC-CT Hybrids* (1003965)—was published on the technical and performance characteristics of a 250-kW SOFC-microturbine system.
- A report—*Assessment of SOFC Systems for C&I Applications* (1003966)—was published to provide validated bench-scale and field test data on small SOFC cogeneration systems.
- A report—*5 kW Fuel Cell for Telecom and Residential Markets* (1003967)—is in process, and will be published March 31, 2002. The report will describe performance, cost, and durability information on emerging residential fuel cell systems.
- A report—*50-kW PEM Prototype Fuel Cell System, Interim Report* (1003968)—is in process and will be published March 31, 2002. The report will describe the performance of PEM fuel cell systems for commercial and industrial applications.

7. Fuel Cell—Energy Storage Systems

- A report—*Technology Assessment of Fuel Cell—Energy Storage Systems* (1004544)—was published, detailing the performance of a PEMFC-Ultracapacitor system for stationary battery replacement markets.

8. Interconnection Hardware

- A report—*Technology Assessment of Interconnection Products for Distributed Resources* (1003969)—was published to provide an annual report on vendors, product development efforts, and R&D issues related to interconnection and switchgear technology.
- A report—*Capacitor-Stabilized Soft Transfer Interface System for Distributed Resources* (1003970)—was published to report on development and testing of a prototype device that can improve the performance, reliability, and economics of DR systems.

Project Status:

This project is complete.

Target 86 Enterprise Infrastructure Security (EIS)

Contract #: 100-98-001

Contractor: EPRI

Contract Amount: 2001: \$45,000

Match Funding: 2001: \$1,209,615

Contractor Project Manager: Jim Fortune, (650) 855-2500

Commission Project Manager: Laurie ten Hope
(916) 654-5045

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to address concerns over the security of the energy industry's electronic infrastructure against cyber and physical threats. These threats range from corporate espionage by competitive rivals to sabotage by hackers or terrorists. Immediate concerns center on the vulnerabilities of electronic operations systems such as supervisory control and data acquisition (SCADA) and plant distributed control systems (DCS) and their interconnectivity with corporate business systems. As the energy industry becomes increasingly automated and electronically connected, a concerted cyber attack could be catastrophic from business, customer and national security perspectives. This project identifies and addresses security issues through a series of working group meetings that include staff and managers from CEC and other agencies, with the ultimate goal of developing more robust electronic security programs. Meetings and workshops provide forums for sharing information on best practices, lessons learned, and vulnerability assessment results.

This project supports the PIER goal of:

Improving the reliability of California's electricity by leveraging the collective knowledge of the participants to develop strategies for protecting the state's critical electric power infrastructure against cyber and physical threats.

Proposed Outcomes:

- Organize and facilitate workshops for collaborative exchange of information and ideas to support the development of robust security programs.
- Provide guidelines, policies and procedures reflecting the collective knowledge of the industry for the following activities:
 - specifying equipment procurement
 - performing tradeoffs between equipment performance and security
 - interfacing between information technology (IT) and

operating systems.

- Enhance the dedicated EIS website with expanded content to provide more and higher value information.
- Engage key operating systems vendors and collaboratively develop security-based functional specifications for new hardware and software.
- Develop a risk assessment framework to help decision makers understand and evaluate the costs and benefits of different security measures.

Actual Outcomes:

- Workshops – Four topical workshops were delivered in 2001
- Guidelines, Policies and Procedures – The following technical reports were published in 2001 and are available on the members-only EIS web site:
 - Equipment Procurement Guidelines
 - Performance/Security Tradeoff Guidelines
 - Interfacing IT and Operations Systems Guidelines
 - Generic Policies and Procedures
- Website
 - The EIS member website was expanded.
- Security-Based Specifications
 - A technical report was published that describes generic specifications for operating system software and hardware resulting from the collaborative efforts of vendor action groups.
- Risk Assessment Framework
 - A web-accessible risk assessment framework was developed.

Project status:

This project is complete.

Assessing California Reserve Margins

Contract #: 100-98-001 **Project #:** 52

Contractor: Electric Power Research Institute (EPRI)

Project amount: \$25,000

Contractor Project Manager: Gary Geschwind
(650) 855-2087

Commission Contract Manager: Mark Rawson
(916) 654-4671

Commission Contract Manager: Gary Klein (916) 653-8555

Project Description: The purpose of this project is to develop a report summarizing the value of adequate reserve margins for California and the Bay Area, particularly the San Francisco-San Jose corridor. This project will develop information to help answer the question: What is the risk of California electric customers experiencing power outages at varying levels of California generating reserves?

Part of the PIER Program's responsibility relates to providing a reliable supply of electric power to California ratepayers. It is, therefore, important for the Commission and the California Consumer Power and Conservation Financing Authority (CP&CFA) to understand what risk is associated with any planned or attained reserve margin of generation resources of all types in attempting to ensure adequate reserve margins to supply all the state's electricity needs.

This project supports the PIER Program objective of:

- Improving the Reliability/Quality of California's Electricity by improving understanding of how adequate reserve margins can reduce the frequency, duration, and cost of outages.

Proposed Outcomes:

1. Develop a better understanding of how decentralized electric generation and non-generation options might reduce the frequency and length of outages and customer outage costs.
2. Compare the value of more peaking and customer units to increased reserves.
3. Determine how the options in task 1, above, might provide insurance against spot market price volatility due to the presence of market power at the margin.
4. Identify principal barriers to the implementation of renewable distributed generation in California and the ways the CP&CFA can remove or alleviate these barriers.

Project status:

The project team delivered a final report to PIER and the California Power Authority in early 2002. The report describes the value of reserves as insurance in an uncertain world, covers distributed energy resources and distributed generation and their potential role in reducing outages discusses the impact of load management (conservation, real-time pricing, and curtailment) and identifies barriers to the implementation of renewables as well as opportunities for removing those barriers. This project is complete.



**Projects Funded through
the Energy Innovations
Small Grant Program
PIER Program Area**

- Projects Funded in 2002
- Projects In Progress
- Projects Completed



SOLICITATION 01-02 AWARDS

Approved May 8, 2002

Proposals Received: 117 Grants Approved: 12 (\$892,011)

Passed Screening: 35 Grants Funded: 12 (\$892,011)

Agripower-Renewable Generation; Agricultural Waste & Forest-Thinnings-to-Energy

EISG Grant Number: 01-10

PIER Area: Renewable Energy Technologies

Principal Investigator: Harvey F. Brush

Contact Information: Phone: (916) 261-2981,

email: info@pmcproduction.com

Organization: PMC Biomass, LLC.

Grant Amount: \$74,605

Project Description: The purpose of this project is to research the feasibility of a new biomass combustion turbine that uses an open Brayton Cycle and modular design. This project will perform component and system testing with particular emphasis on the fuel feed and fluidized bed combustion control system. Farms and orchards generate nearly 8 million dry tons of agricultural waste each year and use about 175 trillion Btu's annually. These biomass wastes represent some 120 trillion Btu's that could take the place of natural gas in generating process heat or electricity. Specific goals of the Agripower are to:

- Utilize in-woods waste as a fuel while reducing or eliminating transportation costs.
- Create energy (possible 120 trillion Btu's annually just from farms and orchards) from agricultural waste with relief of dependency on the grid for many agricultural industries.

The electricity can be used to power machinery to create other value-added products (e.g. using a mini-mill in the woods to manufacture cants for pallets, operate a chipper or hammer mill, and the drying of agricultural matter for fuel). Excess electricity can then be used to power agricultural plants or in the in-woods application, sold back to the local electric utility as a source of green power or distributed generation.

Proposed Outcomes:

- A 200kW biomass powered prototype generator.
- Computerized control software.
- Feasibility analysis of fuel feed system based on performance of prototype system.

Anticipated Benefits:

- Provide a cost effective and environmentally friendly solution to converting a variety of waste biomass feedstocks into

electricity and heat. CA produces about 9.8 Mil tons of annual forest, mill and urban wood residue, which is the primary targeted feedstock.

- Projected cost (capital and operating) of power generation is \$.06/kWh without cogeneration. With cogeneration the cost can be further reduced.

Project Status:

Fuel Feed System - 0%

Design and Program Instrumentation, Controller - 8%

Real Time Energy Meter Radio Frequency Communications System

EISG Grant Number: 01-11

PIER Area: Strategic Energy Research

Principal Investigator: Elsmore William Bush

Contact Information: Phone: (760) 798-2666,

email: e.bush@worldnet.att.net

Organization: Individual

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of integrating narrowband VHF radio communications capability with selectable relay control into a DRM-2000 real time electric meter that will collect, record, and transfer electric meter data to a central location. Real Time Energy Meters (RTEM) allow utilities to establish an hourly rate structure that discourages usage during more expensive peak usage periods. Leveling peak usage reduces the need for less environmentally friendly generators. It can also provide significant savings to the residential customers.

Expected advantages of the adaptable narrowband VHF over UHF system include the following:

- Under isotropic conditions the VHF has a six-to-one free space range advantage.
- Improved structure penetration.
- Improved terrain following that will result in better coverage and less shadowing.
- Lower parts count insures increased MTBF (mean time before failure).
- Lower cost for parts operating at a six to one lower RF frequency.

- The selectable relay control will improve data acquisition reliability.
- Data acquisition time will be reduced as the result of relaying data only where direct data transfers are not possible.
- Improved thru-put by changing relay positions when marginal or varying conditions are encountered.

Proposed Outcomes:

- A prototype real time electric meter with RF communications capability.
- A meter firmware program that incorporates the relay option and avoids energy measurement interrupts during the meter selection interrogations.
- Central control system with RF communications capability.
- Feasibility analysis based on performance of prototype system.

Anticipated Benefits:

- Proposed system offers the potential for low cost and reliable real time metering for residential and commercial electrical consumers. This will reduce the cost of meter reading and allow for real time pricing incentives that will encourage load shifting from peak to off peak.
- Potential to have a real time electronic meter that is cost competitive to the current electro-mechanical meter that sells for \$40.
- Potential to provide electric consumers with real time electrical consumption data that would enable them to manage their power consumption more effectively.

Status:

- Printed Circuit board Layout and Fabrication - 100%
- Order and Receive parts - 80%
- Assemble a Meter and Bench test the unit - 75%
- Check Output Power and Receiver Sensitivity - 50%
- Modify Meter Firmware - 20%
- Modify Base Station Software - 10%

Field Feasibility Determination of a Novel Energy-Saving Refrigeration Controller

EISG Grant Number: 01-12

PIER Area: Residential and Commercial Buildings

Principal Investigator: Patrick D. French

Contact Information: Phone: (303) 792-5615,
email: Patrick.French@adatech.com

Organization: ADA Technologies, Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to

research the feasibility of developing a frost sensor, microcontroller, and special algorithm to fine-tune the defrost cycle for industrial/commercial refrigerators by activating and terminating defrost cycles only when frost appears on the evaporation coil. ADA will perform a field evaluation of this novel device and determine the actual energy savings under real-world conditions. For this project, the prototype controllers will be installed in operating commercial refrigeration systems in California to quantify and document the actual energy savings and the associated improvement in temperature regulation. By determining the actual energy savings of demand defrost under real world conditions in this project, the stage will be set for cost/benefit calculations to be made

Proposed Outcomes:

- Prototype frost sensor microcontrollers for use in field tests.
- A model to predict energy savings.
- Modified firmware that includes additional alarm conditions.
- Feasibility analysis based on performance of prototype system.

Anticipated Benefits:

- The proposed demand defrost system has the potential to reduce refrigerator energy consumption from 6 to 15% by reducing the number and length of defrost cycles.
- This has the potential to save 0.34 quads of electrical energy from commercial refrigeration in the U.S. based on the following assumptions (6304 quads consumed in this category, 11% improved efficiency, and 50% market penetration).

Status:

- Prepare Equipment for Field Testing - 95%
- Prepare for Field Test - 90%
- Collect, process and Analyze Data - 5%
- Develop Energy Savings Calculator - 0%

Development of an Effective Fire-Shield for Powerpoles by Custom Tailoring a Mineral Polymer Material

EISG Grant Number: 01-13

PIER Area: Strategic Energy Research

Principal Investigator: Clem Hiel

Contact Information: Phone: (626) 351-2082,
email: clemhiel@aol.com

Organization: Composite Support & Solutions, Inc. (Now known as BlazeBarrier, Inc.)

Grant Amount: \$74,510.25

Project Description: The purpose of this project is to research the feasibility of developing a low cost fire shield for power poles made out of a newly developed mineral polymer material and glass fibers. A pole Fire-Shield is simply a protective sleeve applied around a wood pole, starting at ground level and extending up to about three times the height of the surrounding brush. These pole fire shields are of vital importance to the California utilities because they effectively increase the survivability of electrical transmission and distribution poles during raging brushfires. Electrical utility experience substantiates that fires consume unshielded poles in a few minutes. This creates an important energy delivery problem in the form of extended outages suffered by the California consumers because the effort of setting new poles typically takes one to several weeks to complete.

BlazeBarrier, Inc. will create a novel Fire-Shield based on its newly developed Inorganic Mineral Polymer (MIP), that is non alkaline. This Mineral Polymer is made at room temperature, using a two-phase system, which develops into a durable three-dimensional network structure. The fact that the material is made at room temperature contributes to its lower cost, energy efficiency, and environmental benefits.

The basic MIP material has the one disadvantage that cracks readily propagate because the material has no inherent crack arresting mechanism, to stop a crack once it has initiated. BlazeBarrier's research proposes to solve this problem by creating a composite material that consists of glass fibers distributed throughout the MIP material. This custom tailored material will blend the excellent fire barrier properties of the Mineral Polymer with the toughness properties needed for it to function as a pole Fire-Shield.

Proposed Outcomes:

- Prototype test samples of new fire-shield material.
- A comprehensive mathematical model.
- Feasibility analysis based on performance of prototype material.

Anticipated Benefits:

- Potential low cost alternative to the current expensive and less effective pole shields that are being used in place of the asbestos shields that are being removed for environmental reasons.
- Potential to increase grid reliability by reducing outages caused by fires near transmission lines.

Status:

- Requirements Definition - 100%
- Trade Study - 100%

- Fabricate and test Toughening - 100%
- Comparative Fire Testing - 50%
- Correlation - 0%
- Cost% Quantitative Estimates of Improvements - 0%

Microturbine Based Building Energy System

EISG Grant Number: 01-14

PIER Area: Building End-Use Efficiency

Principal Investigator: Nissen A. Jaffe

Contact Information: Phone: (650) 961-1341,
email: jafhen@pacbell.net

Organization: Individual

Grant Amount: \$68,058

Project Description: The purpose of this project is to research the feasibility of using a variable, partial, recuperator exhaust by-pass on a natural gas fired microturbine that would allow the turbine to be used for absorption cooling, space heating and power generation in commercial buildings. A feature which distinguishes microturbines from conventional small gas turbines is the recuperator, a heat exchanger used to pre-heat combustion air with exhaust products.

The project will focus on determining the feasibility of employing the recuperator exhaust by-pass to facilitate the following waste heat applications:

- Absorption cooling;
- Space heating; and
- Domestic hot water production.

An adjustable fraction of the microturbine exhaust will be diverted from the recuperator and used to produce a higher temperature waste heat stream. Absorption equipment operating off of microturbine exhaust without supplemental firing is limited to single effect systems having a nominal coefficient of performance (COP) of 0.6; raising the temperature by using a recuperator by-pass offers the potential of operating double effect absorption systems having a nominal COP of 1.2.

Proposed Outcomes:

- System design
- Model of building profiles for energy supply, power demand and thermal demand.
- Economic analysis of the proposed system.
- Feasibility analysis of microturbine exhaust diversion system.

Anticipated Benefits:

- This technology seeks to optimize the energy efficiency of microturbines in commercial building applications, which

could reduce their energy consumption from the grid by up to 80% by shifting the load to natural gas.

- It is projected that the proposed system could achieve a combined cycle peak efficiency of 85% with an average annual efficiency of 55%.
- Projected payback period is estimated to be between 1.8 and 3.9 years depending on the amount of waste heat that can be utilized.

Status:

- Establish Feasibility of variable recuperator by-pass - 75%
- System and Building Model Development - 10%
- System Optimization - 0%
- System Design - 0%
- Economic Evaluation - 0%

Ultra Reduced Emissions Burner for Gas Turbine Combined Cycle (GTCC) and Combined Heat and Power (CHP) Applications

EISG Grant Number: 01-15

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: John T. Kelly

Contact Information: Phone: (408) 982-2302,
email: john@altextech.com

Organization: Altex Technologies Corporation

Grant Amount: \$74,933

Project Description: The purpose of this project is to research the feasibility of a duct burner design for gas turbine, combined-cycle systems that can divide the flame into several zones thereby allowing better control of flame stability, CO emissions and NO_x emissions. Altex Technologies Corporation has identified a duct burner concept, called the Ultra Reduced Emissions Burner (UREB), which can produce stable flames and very low NO_x emissions. This can be accomplished because the burner divides the flame into several zones that are able to balance the usually conflicting requirements of flame stability, flame quality, CO and NO_x emissions. Conventional duct burners using a single flame zone makes it impossible to optimize all of the flame qualities mentioned. Preliminary calculations and tests suggest that the fully-developed UREB may be able to lower NO_x to 1ppm at 15% O₂.

Proposed Outcomes:

- A prototype duct burner that achieves 2ppm NO_x and 6ppm CO at 15% O₂.
- Feasibility analysis based on performance of prototype system and economic evaluation.

Anticipated Benefits:

- Potential to reduce the cost of power from gas turbine combined cycle systems by reducing or eliminating the need for expensive post combustion NO_x controls.
- Potential to reduce the cost of NO_x removal by 90% relative to Selective Catalytic Reduction (SCR) technology.
- Estimate potential savings of \$29 Mil/year from GTCCs and an additional \$63 Mil/year if used in combined heat and power (CHP) system.

Status:

- Fabricate Ultra Reduced Emissions Burner (UREB) Test Burner and System - 39%
- UREB Tests - 0%
- UREB Evaluation - 0%

Flexible Low Emissions Combustor (FLEC) for Renewable Fuels

EISG Grant Number: 01-16

PIER Area: Renewable Energy Technologies

Principal Investigator: John T. Kelly

Contact Information: Phone: (408) 982-2302,
email: john@altextech.com

Organization: Altex Technologies Corporation

Grant Amount: \$74,959

Project Description: The purpose of this project is to research the feasibility of developing a flexible low emissions biomass combustor for renewable fuels that are poorly formed, inconsistently sized and contain high moisture. FLEC uses special features to handle inconsistently sized and high moisture wastes. In addition, an aggressive ash handling method is utilized to avoid deposition on heat transfer surfaces and passages, and positively remove ash from the system. With FLEC, nearly all plant wastes can be converted into energy at a cost that will be close to that of converting fossil fuels and will further the use of plant wastes for power generation, while helping reduce the air pollution associated with electricity generated with fossil fuels.

Proposed Outcomes:

- A prototype test FLEC
- Feasibility analysis based on performance and economic evaluation of prototype.

Anticipated Benefits:

- Provide a cost effective and environmentally clean solution to converting low value biomass materials to useful electrical energy.

- Reduce the cost of biomass combustion by 30% relative to grate based and fluidized bed systems.

Status:

- Prepare FLEC test combustor and materials - 100%
- FLEC Tests - 100%
- FLEC Evaluation - 18%

Spectrally Enhanced Ceramic Incandescent Emitter**EISG Grant Number:** 01-17**PIER Area:** Building End-Use Efficiency**Principal Investigator:** Devon R. McIntosh**Contact Information:** Phone: (301) 283-6250, email: dr_mcintosh@hotmail.com**Organization:** Sonsight Inc.**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of a new type of composite ceramic oxide emitter for an incandescent light bulb that is 300% more energy efficient than conventional incandescent bulbs and produces light that is closer to the natural sunlight spectrum with an expected color rendering that is superior to other general lighting sources. Its optical scattering and spectral absorptivity are designed to produce a spectral distribution that is much greater within the visible spectrum.

The innovation is based on:

- utilizing a novel heating arrangement to attain high, stable incandescent temperatures, and
- optically and physically structuring a composite ceramic oxide emitter such that when heated as designed, it emits, within the visible spectrum, a much larger portion of its total radiated power than that emitted by state-of-the-art incandescent bulbs.

Proposed Outcomes:

- Produce a prototype of new ceramic incandescent emitter.
- Produce a thermal model, which includes internal optical scattering.
- Provide a feasibility analysis based on performance of prototype emitter.

Anticipated Benefits:

- Potential to increase the energy efficiency of incandescent light bulbs by 300%.
- Eliminate the need for mercury that is used in fluorescent and HID lamps and is becoming a growing environmental problem.

- Health and performance benefits that derive from using full-spectrum lighting.

Status:

- Determine Baseline Efficiency at 2650 oK - 85%
- Fabricate and Characterize Baseline Emitter - 50%
- Extend Electro-Thermal Stability Model - 15%
- Fabricate and Characterize Tube Emitter - 0%
- Structure, Characterize and Optimize Internally heated Emitter - 0%

High-Volume Manufacturing for Low-Cost, Flexible Solar Cells**EISG Grant Number:** 01-18**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Shalini Menezes**Contact Information:** Phone: (805) 497-2677, email: interphases@att.net**Organization:** InterPhases Research**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of developing a new flexible thin-film solar cell based on negatively doped (n) copper indium diselenide (CIS) with fewer cell components relative to the state of the art, positively-doped (p)-CIS cell. The CIS PV cells are more efficient and reliable than other thin-film technologies. The state-of-the-art technology is based on positively doped (p)-CIS rigid glass panels, fabricated with expensive, hazardous methods that are difficult to scale up for mass production. The proposed n-CIS cell will circumvent these issues. It will use fewer cell components and a simpler, cheaper manufacturing approach. The flexible n-CIS cell will be produced via electrodeposition on a metal tape for large volume manufacture. Low cost electrodeposition incorporates the environmental benefits, low temperature growth, efficient material utilization and practical deposition rates. The same laboratory-scale equipment can be used for a MW-scale plant production.

Proposed Outcomes:

- Manufacturing methodology for deposition of n-CIS film;
- Prototype n-CIS PV cell;
- Photoelectrochemical and composition analysis;
- Efficiency and stability analysis; and
- Feasibility analysis based on performance of prototype cell.

Anticipated Benefits:

- Reduce thin film production cost from \$26/m² to about \$2/m² resulting in a 75% reduction in PV module cost.

- Eliminate the need for cadmium in the PV modules, which reduces the potential for environmental damage.

Status:

- Devise New Configuration and Method -30%
- Construct a PV Cell - 20%
- Analyze the Films - 30%
- Fabricate and Analyze Devices - 0%

IEM's Low Cost Building Performance Infrared Camera**EISG Grant Number:** 01-19**PIER Area:** Building End-Use Efficiency**Principal Investigator:** Zack Mian**Contact Information:** Phone: (518) 449-5504x11,
email: zack786@nycap.rr.com**Organization:** International Electronic Machines Corp.**Grant Amount:** \$74,946

Project Description: The purpose of this project is to research the feasibility of incorporating cost-cutting innovations in the design of an infrared camera that will reduce the retail cost from \$12,000 to less than \$2,500, thereby expanding their use in energy audits of commercial and residential structures.

Performance monitoring projects across the U.S. have documented the potential to conserve 15% to 30% of energy use through improved operation and maintenance practices. An important step towards performance monitoring is to establish the energy efficiency of the building. Energy losses can come from a number of areas: direct loss from windows/doors; missing insulation in ceilings, walls or floors; inadequate caulking / weather stripping; or lack of duct or piping insulation.

During an energy audit, an expert performs heat loss measurements on the property among other steps. Thermal infrared imaging cameras have become an invaluable tool in performing energy audits in commercial as well as residential applications. The infrared camera has the ability to display the energy loss as an at-the-source image. This image provides an easy to use picture to assist the energy auditor. The high investment cost of an infrared camera is prohibitive to many energy contractors, and a less costly energy-loss tool with the same high-quality image properties will greatly increase their availability and use in the industry.

Proposed Outcomes:

- A prototype IR camera unit.
- Field study by energy performance contractors.

- Feasibility analysis based on performance of prototype system.

Anticipated Benefits:

- Potential to improve energy audits performed by energy auditors/consultants, building contractors, electrical inspectors and utility companies.
- Improved operating and maintenance practices have the potential to reduce building energy consumption by 15-30%.

Status:

- Meeting BPCA requirements - 50%
- Sensor Module - 80%
- Optics - 75%
- On-Board Controller - 60%
- Motion Control System - 60%
- Main Control Module - 70%
- Manufacturing Optimization - 10%
- Build Prototype - 10%
- Test Prototype Camera - 0%

Quantitative Building Cooling of Tile Roof's Coated with Solar Infrared (IR) Reflective Coatings**EISG Grant Number:** 01-20**PIER Area:** Building End-Use Efficiency**Principal Investigator:** Joseph C. Reilly**Contact Information:** Phone: (714) 680-6436,
email: jcr@cruznet.net**Organization:** American Rooftile Coatings**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of new IR reflective coatings that can be applied to residential concrete or clay tile roofs to achieve a minimum 40% solar reflectance. American Rooftile Coatings is exploring new infrared reflecting architectural coatings for on-site application to steep-pitched concrete or clay tile roofs for the purpose of improving a home's appearance and also reducing its consumption of energy. While flat sloped roofs lend themselves to an easy switch from black to white and subsequent energy savings, steep pitched roofs are more problematic, especially regarding color choice. Aesthetically pleasing colors are important because the roof is about 50% of what one sees from the curb and darker colors are often the choice of a homeowner.

Mixed metal oxide pigments developed for the military in the 1980-s demonstrate superior infrared reflectivity. Coatings based on those pigments show improved infrared reflectance in

laboratory testing. No conclusive tile roof tests have been published that demonstrate that such IR coatings substantially lower a home's temperature and energy use. American Rooftile Coatings (ARC) has taken a trademark out on 'COOLTILE IR COATINGS'TM with the hope that such coatings will lead to cooler roof temperatures and compete in the cool roof market place.

The object of this study is to quantify reductions in tile roof temperatures, building cooling power demand and energy usage that is achieved by refinishing roof tiles with IR reflective coatings. American Rooftile Coatings proposes to monitor the roof and interior temperatures of several adjacent pairs of tile-roofed model buildings. The test site will be located in an inland Southern California area to maximize the impact of the power savings in a hot, dry climate.

Proposed Outcomes:

- Produce five experimental IR reflective coatings of different primary colors
- Building energy simulation models for collecting temperature data and computing the reduction in cooling power demand and cooling energy usage by applying the IR coatings.
- Feasibility analysis based on performance of prototype coatings.

Anticipated Benefits:

- Reduce the cooling load in residential homes with steep-pitch cement or clay tile roofs.
- Reduce roof deck temperature 10-20%.
- Coatings could be used on existing homes as a retrofit product, which increases the potential impact of decreased peak load cooling.

Status:

- Acquire Test Site - 100%
- Mfg. Model Buildings - 100%
- Mfg. Paint - 100%
- Install Coated Tile - 22%
- Test Tile in Lab - 14%
- LBNL install Temperature probes - 90%
- LBNL install data loggers & uplink capability - 100%
- Initiate & Conduct Testing - 20%

Improvement of Rechargeable Lithium-ion Batteries Performance by Surface Modification of the Cathode

EISG Grant Number: 01-21

PIER Area: Renewable Energy Technologies (RET)

Principal Investigator: Pieter Stroeve

Contact Information: Phone: (530) 752-8778,
email: pstroeve@ucdavis.edu

Organization: University of California, Davis

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of using lithium manganese oxide as a cathode material in rechargeable lithium ion batteries to achieve higher voltage, lower cost and increased safety. One of the main reasons for capacity fading is manganese (Mn) dissolution from the surface of the battery. Research to halt the dissolution of Mn into the electrolyte solution using polymer coatings and/or crown ether modification on molecular scale will be applied. RET will investigate if polymer coatings on the surface of the LiMn_2O_4 (lithium manganese oxide) particles before cathode fabrication will lead to a hindrance of the Mn^+ dissolution, while still allowing adequate transport of Li^+ (positively charged lithium ions) to the cathode material. Utilizing the property of crown ethers to trap metal ions, RET will coat the surface of the LiMn_2O_4 particles with crown ethers, which can inhibit Mn dissolution. The method proposed for surface-modified LiMn_2O_4 particles is feasible and can extend the lifetime of the battery by arresting the Mn^+ (positively charged manganese ion) dissolution, increasing the battery stability, thus the need for proof of concept testing.

Proposed Outcomes:

- Produce two prototype polymer cathode coatings.
- Produce a feasibility analysis based on performance of prototype cathode coatings.

Anticipated Benefits:

- Reduce the cost of energy storage in distributed power generation systems.
- Potential to contribute to grid stability and power quality by making low-cost batteries for electricity storage available.
- Potential to reduce the manufacturing cost of lithium ion batteries by 10-20%.
- Potential to reduce capacity fading in lithium ion batteries.

Status:

- Identify electrochemical properties and surface compounds that may be chemisorbed on the surface as intermediates - 75%
- Evaluate the surface modification of the cathode material in organic electrolyte using in situ Electrochemical Atomic Force Microscopy - 25%

SOLICITATION 01-03 AWARDS

Approved August 28, 2002

Proposals Received: 78 Grants Approved: 8 (\$598,081)

Passed Screening: 33 Grants Funded: 8 (\$598,081)

Desiccant Enhanced Indirect/Direct Evaporative Cooling System

EISG Grant Number: 01-22

PIER Area: Building End-Use Efficiency

Principal Investigator: William A. Belding

Contact Information: Phone: (925) 743-1775,
email: wbelding@ireconsulting.com

Organization: Innovative Research Enterprises

Grant Amount: \$74,900

Project Description: The purpose of this project is to demonstrate the feasibility of a new air conditioning design that incorporates indirect/direct evaporative cooling and dehumidification with gas regeneration. The proposed indirect/direct system employs desiccant components within the indirect cooling stage, thus simultaneously dehumidifying and cooling the process air. With the proposed technology, a single component will perform at improved efficiency, the functions now performed by a desiccant dehumidifier and a heat exchanger. Having improved performance over existing techniques, the system can be used as a total cooling solution for western climates and eliminate the need for conventional vapor compression systems.

Proposed Outcomes:

- A prototype heat exchanger will be built and tested as part of the project.

Anticipated Benefits:

- System design capable of SEER rating greater than 30 as opposed to traditional vapor compression units, which have a SEER of 10-16.
- Potential to shift some of the peak electrical load used for AC to natural gas.
- May increase comfort and indoor air quality by supplying up to 100% outdoor air to the conditioned space.

Status:

- Develop Desiccant Application Techniques for Heat Exchanger Partitions - 80%
- Fabricate Heat Exchanger - 0%
- Do Performance testing - 0%
- Determine Cost Benefits - 20%

Energy-Efficient Process for Using Membrane Technology to Treat and Recycle Agricultural Drainage Water

EISG Grant Number: 01-23

PIER Area: Industrial/Agricultural/Water End-Use

Principal Investigator: Ronald J. Enzweiler

Contact Information: Phone: (925) 283-4918,
email: ron@h2o-tech.com

Organization: Water Tech Partners

Grant Amount: \$74,788

Project Description: The purpose of this project is to demonstrate the feasibility of using a more energy efficient two-stage membrane process for desalinating and recycling agricultural drainage water. Substantially less energy is required to desalinate agricultural drainage using membrane technology than is required for sea water because the drainage water has substantially less salinity. Membrane technology is not presently used to treat and recycle agricultural drainage water because no viable pretreatment process exists. Agricultural drainage water is so hard (up to 2,000 mg/L of calcium and magnesium expressed as calcium carbonate) that scale quickly builds up on the surfaces of the membrane elements. This scale causes the membrane elements to foul and become unusable. Pretreatment by conventional means (e.g., ion exchange or lime/soda precipitation) and/or the use of sequestering agents as scale inhibitors has proven to be impractical or ineffectual in previous pilot tests and field trials.

The objective of this project is to perform proof-of-concept testing of a novel pretreatment process, called "preferred precipitation" nanofiltration, which has the potential to overcome to current barriers to using membrane technology to treat agricultural drainage water.

Proposed Outcomes:

- A two-stage device will be assembled and tested with drainage water in the project.

Anticipated Benefits:

- Produce 80,000 Acre Feet/year of "new water" from agricultural drainage water in California using the two-stage membrane process.
- Restore 250,000 acres of drainage impaired farmland in the Western San Joaquin Valley.

- Reduce the cost of desalination by 25% over the most cost effective methods currently available.
- Improve the water quality flowing into the San Francisco Bay Delta.

Status:

- Assemble Pilot Test System - 100%
- Run Tests - 100%
- Operate using actual drainage water - 60%

Solid State Electrolyte for Dye-Sensitized Solar Cells (DSSCs)**EISG Grant Number:** 01-24**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Russell Guadiana**Contact Information:** Phone: (978) 654-6961, email: rguadiana@konarkatech.com**Organization:** Konarka Technologies, Inc. (KTI)**Grant Amount:** \$74,735

Project Description: The purpose of this project is to research the feasibility of using a specially formulated gel as an electrolyte in dye-sensitized solar cells (DSSCs) that permits effective encapsulation in the manufacturing process. Our specific project goal is to develop a solid-state electrolyte that outperforms the liquid electrolytes presently used for DSSCs, and would represent a significant advance. KTI's proposed research has three key objectives:

1. Develop an electrolyte gel that can be transitioned from liquid to solid at temperatures ranging from 40-90°C, without compromising its performance.
2. Eliminate volatiles from the coating solvents and active components.
3. Achieve cell performance equal to or better than that of liquid electrolytes.

Proposed Outcomes:

- Prototype solar cells will be fabricated and tested as part of the project.

Anticipated Benefits:

- Potential to reduce the manufacturing cost of solar cells to less than \$1 / Wp through low cost materials and roll-to-roll manufacturing.
- Low cost thin film PV would significantly expand the cost effective applications for PV in California.

Status:

- Project Start date 10/15/02 Progress report not yet due.

Prototype and Demonstration of Vision-Tuned fluorescent Lamps**EISG Grant Number:** 01-25**PIER Area:** Building End-Use**Principal Investigator:** Kevin W. Houser**Contact Information:** Phone: (402) 554-3858, email: khouser@unl.edu**Organization:** University of Nebraska-Lincoln**Grant Amount:** \$75,000

Project Description: The purpose of this project is to demonstrate the feasibility of developing more energy efficient fluorescent lamps in which a greater percentage of the radiant energy is used to produce light that is optimized for human vision. A significant opportunity exists to optimize light source spectra, which will lead to better vision with the minimum expenditure of energy.

The prototype lamps will fully embrace trichromacy of human vision, with the goal of eliciting the maximum response from the opponent channels. A minimum of four different types of prototype lamps will be made, varying in the degree that they stimulate the opponent channels. Increasing the opponent channel response will be achieved by maximizing radiant energy output in the three spectral regions near 446, 533, and 610 nm while simultaneously minimizing radiant energy in other parts of the spectrum. The prototype lamps will use conventional manufacturing technologies, but will make use of novel phosphor blends designed to regulate the opponent channel responses. This work will pave the way for large scale production of energy efficient vision-tuned fluorescent lamps.

Psychophysical data will be collected during the evaluations and will be used to demonstrate that the prototype lamps are equivalent to, or exceed the performance of, conventional sources along three dimensions critically important to interior working environments:

1. Visual performance,
2. Brightness perception, and
3. Color rendering.

Proposed Outcomes:

- Prototype lamps will be fabricated and tested as part of the project.

Anticipated Benefits:

- Potential to reduce energy consumption in fluorescent lighting by 20%. Assuming 2.5 quads of electrical energy is consumed by commercial buildings nationwide, there is the potential to save .5 quads with 100% penetration.
- Potential to improve lighting quality with resulting benefits in comfort and productivity.

Status:

- Projected Start date October 1, 2002
- First progress report due no later than 4 months after start date

Low-Cost, High Efficiency Solar Cell Fabrication Using Inkjet Printing**EISG Grant Number:** 01-26**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Neil Kaminar**Contact Information:** Phone: (408-524-9739), email: Nkaminar@SunPowerCorp.com**Organization:** Sun Power Corporation**Grant Amount:** \$74,948

Project Description: The purpose of this project is to determine the feasibility of using low-cost, high-resolution inkjet printing technology to fabricate high-efficiency solar cells. The process SunPower uses to fabricate its solar cells is unique in the solar industry. SunPower's manufacturing is more similar to processes and equipment used by the integrated circuit industry than to other solar cell companies. Achieving high cell efficiency requires patterning very fine device features, about 0.004 inch (100 μm) in size. Presently SunPower uses photolithographic processing to define the very fine patterns needed, but this is very costly. To make lower cost cells, lower cost equipment and processes must be found, while not sacrificing the resolution required for high efficiency.

Inkjet printing offers a possible solution. Resolution of common desktop inkjet printers, selling under \$200, are typically 720 DPI (dots per inch), equating to 35 μm dot spacing. They are also easy to use – just load up the desired pattern and press print. Finally, they are "off contact" meaning that only the ink touches the substrate, unlike other printing techniques.

Proposed Outcomes:

- The project will modify a commercial inkjet printer and formulate special inks, which will be used to physically test the concept.

Anticipated Benefits:

- Potential to achieve cell efficiencies of 21% without an increase in manufacturing cost.
- Potential to reduce PV module cost to \$1.92 dollars per watt by 2005.

Status:

- Projected Start date October 1, 2002
- First progress report due no later than 4 months after start date

Development of Single Fan Multi-Stack Exhaust Systems**EISG Grant Number:** 01-27**PIER Area:** Building End-Use Efficiency**Principal Investigator:** Mingsheng Liu**Contact Information:** Phone: (402) 554-2173, email: mliu2@unl.edu**Organization:** University of Nebraska**Grant Amount:** \$74,805

Project Description: The purpose of this project is to demonstrate the feasibility of a single fan multi-stack laboratory exhaust system that reduces annual fan energy by 50%. California is the world and the national center for development of high-level research technologies and has large numbers of research and high- technology facilities in university campuses, government buildings, and industry plants. In these research facilities, exhaust fans run 24 hours a day and 365 days a year to exhaust toxic air from the laboratories to the outside. The exhaust fans consume considerable electricity and contribute to significant amount of the electrical peak demand. This research will develop a single fan multi-stack system, which will reduce the exhaust fan annual energy significantly for both existing and new facilities.

Proposed Outcomes:

- A prototype system will be fabricated and tested.

Anticipated Benefits:

- Potential to save on average 50% of the fan energy consumed by conventional laboratory exhausts systems.
- Retrofit payback period of only four years.

Status:

- Projected Start date October 1, 2002
- First progress report due no later than 4 months after start date

Automating Window Sunshade Control: Toward the Zero Energy House**EISG Grant Number:** 01-28**PIER Area:** Building End-Use Efficiency**Principal Investigator:** Murray Milne**Contact Information:** Phone: (310) 454-7328, email: milne@ucla.edu**Organization:** University of California, Los Angeles**Grant Amount:** \$74,685

Project Description: The purpose of this project is to demonstrate the feasibility of a new kind of intelligent

thermostat that incorporates outdoors temperature sensors to control automated sunshades to reduce the heat load on air conditioners in the summer. This project will demonstrate the feasibility of a new kind of an intelligent window sunshade controller that can minimize cooling and heating energy costs for California ratepayers. Developing this thermostat-microprocessor to control the operation of shading elements on the building envelope is an important step towards creating a Zero Energy Home.

Already on the market, especially in Europe, are various electrically operable sun control devices. These include awnings that extend and retract, vertical exterior operable louvers, interior operable draperies and venetian blinds. However, none of them has any type of intelligent controller, similar to the microprocessor-thermostat developed in a previous EISG project that could read outdoor temperatures and operate shading devices in order to optimize indoor temperatures.

The project result will be the development of a new enhanced thermostat-controller, a computer program optimized for the best indoor air temperature control, data demonstrating the differences between interior or exterior shades, and recommendations regarding the best way to install and control automated sun controls. An added goal will be to try to interest either a thermostat manufacturer or an automated shade manufacturer into adding such a device to their product line.

Proposed Outcomes:

- A microprocessor controlled thermostat that can sense both indoor and outdoor temperature will be built, programmed and tested as part of the project.

Anticipated Benefits:

- Potential to reduce residential air conditioning costs by reducing the solar heat gained through windows.
- May allow the shades to automatically adjust to weather changes without the need of human interaction.

Status:

- Projected Start date October 1, 2002
- First progress report due no later than 4 months after start date

Test Program for High Efficiency Turbine Diffuser

EISG Grant Number: 01-29

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Thomas R. Norris

Contact Information: Phone: (415) 391-2158,
email: consultants.acoustics@gte.net

Organization: Consultants in Engineering Acoustics

Grant Amount: \$74,220

Project Description: The purpose of this project is to research the feasibility of reducing backpressure on turbines designed with a right angle bend in the outlet by inserting aerodynamic vanes and devices placed inside the exhaust diffuser. The project will demonstrate the viability of a concept previously developed on a small-scale model of a power generation combustion turbine. The application is for gas turbines that have a right angle bend in the exhaust just downstream of the exhaust diffuser. The exhaust diffuser is an aerodynamically shaped duct section located just downstream of the last turbine wheel. An excellent diffuser will improve power and efficiency. The goal is to increase combustion turbine efficiency and power by one percent in most turbines with a right angle bend and by two percent in an older turbine model that is now being remanufactured and installed for peaking purposes. Fuel use is not increased.

Proposed Outcomes:

- A larger turbine exhaust scale model and fan system to replace the present 1/8-size model will be fabricated and tested as part of the project. The expected scale factor is 1/4 to 1/3.

Anticipated Benefits:

- Potential to increase gas turbine efficiency by 1% at little additional cost thereby reducing the cost of power from gas turbines.
- Large potential retrofit market for turbines installations with right angle bends after the exhaust diffuser.

Status:

- Build Scale Model - 20%
- Install Flow Measurement Instruments - 70%
- Build and install flow Improvement Devices - 10%
- Obtain Flow/pressure Measurements - 0%

SOLICITATION 02-01 AWARDS

Approved November 20, 2002

Proposals Received: 57 Grants Approved: 7 (\$519,436)

Passed Screening: 31 Grants Funded: 7 (\$519,436)

Sealing and Contacting to Novel Integrated Solid Oxide Fuel Cells

EISG Grant Number: 02-01

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Scott A. Barnett

Contact Information: Phone: (847) 491-2447,
email: s-barnett@northwestern.edu

Organization: Northwestern University

Grant Amount: \$74,954

Project Description: The purpose of this project is to demonstrate a novel sealing and electrical contacting method for solid oxide fuel cells (SOFCs). The new materials are being developed primarily for a new "integrated" SOFC stack design that has significant advantages over conventional SOFC stacks. The specific objectives are to:

- Determine the feasibility of the new methodology,
- To determine the optimal materials and processing procedures, and
- To fabricate prototype ISOFC stacks complete with seals and contacts, and demonstrate effective performance of the stacks.

The main energy problem targeted by this proposal is to make an economically viable fuel cell stack that overcomes technical difficulties associated with other more conventional approaches. The realization of commercially viable fuel cells would provide electrical power at greater efficiency and thereby lower cost. The use of fuel cells in distributed generation offers the following potential benefits to California ratepayers:

- Reducing harmful environmental emissions that result from central power plants using combustion technologies;
- Reducing the need for power distribution infrastructure;
- Increasing grid reliability; and
- Increasing grid power quality and eliminates power line losses.

Proposed Outcomes:

- Complete integrated Solid Oxide Fuel Cell (ISOFC) stacks using metal brazing for sealing and contacting will be fabricated and tested.

Anticipated Benefits:

- Potential to accelerate the development of fuel cell

technology to achieve the cost and reliability needed in order to be used in distributed generation applications.

- Fuel cells offer the promise of reduced emissions, higher efficiency, increased grid reliability and increased grid power quality.

Status:

- Projected Start date January 1, 2003
- First progress report due no later than 4 months after start date

Low Cost, Energy Saving Motor Controller for Residential and Industrial Buildings

EISG Grant Number: 02-02

PIER Area: Building End-Use

Principal Investigator: Patrick Chapman

Contact Information: Phone: (217) 333-4694,
email: chapman@ece.uiuc.edu

Organization: University of Illinois at Urbana-Champaign

Grant Amount: \$69,482

Project Description:

The purpose of this project is to demonstrate the feasibility of integrating a unique motor drive with a specially designed 3-phase motor that allows the motor to be driven with single-phase power and will vary the speed of the motor to follow the load. Small electric motors collectively waste an enormous amount of energy on a worldwide scale. Many of these small motors are single-phase induction machines for appliances, heating, and air conditioning. However, a single phase motors are generally understood to have base performance worse than three phase motors. With existing electric power distribution, the single-phase machine is more convenient to use than its three-phase counterpart. Therefore, it is desirable to have a three-phase motor that can be driven from single-phase power

Proposed Outcomes:

- A 500 W prototype will be fabricated and tested.

Anticipated Benefits:

- Potential to demonstrate greater than 70% motor efficiency over a 10:1 speed range.
- Potential to achieve a unit cost of less than \$40.

- Potential to save California homeowners up to 25% on their AC energy consumption.

Status:

- Projected Start date January 1, 2003
- First progress report due no later than 4 months after start date

Detecting Optimal Fan Pressure**EISG Grant Number:** 02-03**PIER Area:** Building End-Use**Principal Investigator:** Clifford Federspiel**Contact Information:** Phone: (510) 418-3392, email: cf@federspielcontrols.com**Organization:** Federspiel Controls**Grant Amount:** \$75,000**Project Description:**

The purpose of this project is to research the feasibility of using a new algorithm for more accurately determining the optimal pressure at which to operate variable air volume (VAV) air-handling systems. This project is part of an ongoing effort by the Contractor to improve the efficiency of air-handling equipment. This project will involve the testing and demonstration of a new method of detecting the optimal pressure at which to operate variable air volume (VAV) air-handling systems. The ability to detect this pressure will enable VAV system use less energy during both on-peak and off-peak periods.

Proposed Outcomes:

- A test stand will be fabricated. The test stand will include a computer-based data acquisition system, a supply airflow station and a supply duct pressure sensor.

Anticipated Benefits:

- The proposed algorithm has the potential to enable a reduction in source energy consumption in California of 0.18 quads. The reduction corresponds to an annual cost savings of \$171 million and a reduction in carbon emission of 0.27 million metric tons per year.
- Potential to reduce electrical consumption during peak electrical demand periods.

Status:

- Projected Start date January 1, 2003
- First progress report due no later than 4 months after start date

Fault Location Techniques for Distribution Feeders Containing Distributed Generation**EISG Grant Number:** 02-04**PIER Area:** Strategic Energy Research**Principal Investigator:** Adly Girgis**Contact Information:** Phone: (864) 656-5936, email: adly.girgis@ces.clemson.edu**Organization:** Clemson University**Grant Amount:** \$75,000

Project Description: The purpose of this project is to demonstrate the feasibility of a computational strategy for determining the fault location in a transmission network containing distributed generation resources. Proposed strategy will be based on an analysis of the voltage and current waveforms on the three phase lines at various points in the distribution network.

Locating faults in a distribution feeder is essential to speed the restoration of service and minimize the outage time of the distribution feeder. Introducing distributed generation changes the power flow in distribution systems from a traditionally uni-directional to multi-directional power flow. Thus, there is a need to develop a new method for fault location. The method considers the following factors:

- The distribution feeder may contain single phase loads, two phase loads and three phase loads so system unbalance should be considered;
- The feeder may include any number of distributed generators of different types along the feeder;
- Data at the distributed generators may or may not be communicated to the substation computer.

The voltages at the substation are functions of the feeder currents, the distance to the fault and the currents fed from the distributed generators. When the currents from the distributed generators are not telemetered, the method will utilize an estimation process for the DG currents. The process is an iterative process. The iteration stops when the error is less than 0.001 per unit. The data may be available through digital devices at the substation. These devices may provide raw data as samples of voltage and current waveforms, or provide phasor quantities. If the data is available as samples, the method will start by developing the phasor quantities and proceed to the fault location process.

Proposed Outcomes:

- A couple of algorithms will be developed and utilized. First, an algorithm for calculating the voltage and current phasor quantities needed for the fault location algorithm using

three-phase fault analysis will be developed. Second, a signal-processing algorithm, such as DFT and Kalman filtering, will be developed in order to obtain the phasor quantities when the voltage and current waveforms are obtained from EMTDC software simulations.

Anticipated Benefits:

- Potential to provide California utilities with the ability to incorporate Distributed Generation (DG) into their distribution systems while maintaining the current level of system reliability.

Status:

- Projected Start date January 1, 2003
- First progress report due no later than 4 months after start date

Steady State Security Assessment of Deregulated Power Systems

EISG Grant Number: 02-05

PIER Area: Strategic Energy Research

Principal Investigator: Elham B. Makram

Contact Information: Phone: (864) 656-3378,
email: makram@clmson.edu

Organization: Clemson University

Grant Amount: \$75,000

Project Description: The purpose of this project is to demonstrate the feasibility of a computational strategy for rapidly assessing the state of the transmission network following possible system contingencies. With the inception of deregulation, transmission networks are subjected to a host of bilateral transactions, which would influence physical system quantities like real power flows, security margins and voltage levels. For efficient asset utilization and maximization of the revenue, transmission networks are sometimes operated under stressed conditions, sometimes close to security limits. Therefore, a quantitative assessment of the extent to which each transaction adversely affects the transmission network is required.

Proposed Outcomes:

- A voltage instability indicator and distribution factors using the Jacobian matrix will be developed and utilized.

Anticipated Benefits:

- Potential to enable the electrical utility to accurately and quickly assess the various state variables of the transmission networks following contingencies that would allow mitigating actions to be taken to ensure the reliability of the system.

- Potential to support the deployment of distributed generation resources by allowing the electrical utility to assess the impact specific distributed generation systems would have on the transmission network if they were brought on line.

Status:

- Projected Start date January 1, 2003
- First progress report due no later than 4 months after start date

High Efficiency Organic Thin Film Solar Cell

EISG Grant Number: 02-06

PIER Area: Renewable energy Technologies

Principal Investigator: Shalini Menezes

Contact Information: Phone: (805) 497-2677,
email: interphases@att.net

Organization: InterPhases Research

Grant Amount: \$75,000

Project Description: The purpose of this project is to demonstrate the feasibility of a low cost organic thin film solar cell device that can be fabricated using a simple robust process for organic/polymeric materials. Barriers to the widespread use of solar cells (photovoltaics) are mainly cost-related. Organic solar cells have many practical advantages ensuring their low cost production and product competitiveness. They include:

- Simple, non-toxic and inexpensive materials,
- Lightweight and flexible plastic substrate,
- Excellent possibility,
- Amenability to state-of-the-art, robust processing technologies such as coating and continuous roll-to-roll production, and
- Large area and high volume production.

Lightweight, flexible organic solar cells will find applications in portable electronic devices, portable electricity systems, electric vehicles, space systems and building integrated PV, among others. Organic solar cells can also be transparent or mono-colored and thus can be used in see-through applications such as windows and sunroofs.

Proposed Outcomes:

- A solar cell will be constructed based on the proposed concept.

Anticipated Benefits:

- Proposed technology has the potential to increase the conversion efficiency of organic thin film solar cells to at least 5% while keeping cost low.

- Proposed technology has the potential to provide low cost, high volume production of flexible thin film solar cells from inexpensive, easily processed organic and polymeric materials.

Status:

- Projected Start date January 1, 2003
- First progress report due no later than 4 months after start date

Unified Power Quality Conditioner Using One-Cycle Control**EISG Grant Number:** 02-07**PIER Area:** Industrial/Agricultural/Water End-Use Efficiency**Principal Investigator:** Keyue Smedley**Contact Information:** Phone: (949) 824-6710, email: smedley@uci.edu**Organization:** University of California, Irvine**Grant Amount:** \$75,000**Project Description:**

The purpose of this project is to demonstrate the feasibility of using the applicant's patented One-Cycle Control (OCC) circuit design to simplify and reduce the cost of a Unified Power Quality Conditioner (UPQC) that can compensate for reactive power flow, harmonic distortion, and voltage variation/sag. UPQC is a device that is connected in the utility side of the sub-

station to control power flow, regulate the voltage against sag/swell, and eliminate harmonic and reactive current. It is an indispensable element for distributed power generation. The proposed UPQC functions as variable impedance. The value and phase of this impedance can dynamically adjusted to steer the power flow to the right direction as well as regulate the voltage while the frequency characteristics can be adjusted so that the impedance to harmonics is maximized to resist harmonic current flow.

Proposed Outcomes:

- A 5KW three-phase bench-scale prototype of One-Cycle Control Unified Power Quality Conditioner (OCC-UPQC) will be fabricated and tested.

Anticipated Benefits:

- Potential to reduce California electrical consumption by 10% if installed in 50% of the utility electrical substations.
- May increase the capacity of the California transmission system by 5%.

Status:

- Projected Start date January 1, 2003
- First progress report due no later than 4 months after start date



SOLICITATION 01-01 AWARDS

Biofiltration Abatement of Landfill Gas Energy Exhaust Pollutants EISG Grant

EISG Grant Number: 01-01

PIER Area: Energy-Related Environmental Research

Principal Investigator: Don Augenstein

Contact Information: Phone: (650) 856-2850,
email: iemdon@aol.com

Organization: Individual

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of a biofiltration strategy to clean the exhaust of an internal combustion engine running on landfill gas. Landfill solid waste will be used as the primary contact medium in the biofiltration system. If this technique proves viable as expected, laboratory data will be extrapolated to full-scale system performance and costs.

Proposed Outcomes:

- Cost and performance projections will be made based on data obtained.
- Plan for full-scale testing if results from this project are encouraging.

Anticipated Benefits:

- Allow recovery of about 300-500MWe of landfill gas electric generation potential that is now stalled in California due to excessive pollutants in energy equipment emissions.

Status:

- Assemble Laboratory Reactors - 20%
- Develop analytical techniques for exhaust pollutants of greatest concern - 30%
- Examine abatement kinetics under various gas flow regimes and biofilter characteristics - 0%
- Estimate cost for application of full-scale biofiltration - 0%
- Plan large-scale tests- 0%

Flywheel Energy Storage Units in Power Distribution Networks

EISG Grant Number: 01-02

PIER Area: Energy Systems Integration

Principal Investigator: John Balachandra

Contact Information: Phone: (916) 972-9411,
email: elcomusa@cwnet.com

Organization: ELCOM

Grant Amount: \$74,888

Project Description: The purpose of this project is to research the feasibility of incorporating flywheel energy storage

units into a micropower distribution system to improve power quality, reliability and voltage stability.

Proposed Outcomes:

- Assemble a micro power distribution system with a 2 kW Flywheel Energy Storage Unit integrated into the system.
- Determine the ability of the Energy Storage unit to maintain power quality within a micro power distribution system.

Anticipated Benefits:

- A capability to respond to and mitigate power distribution system voltage variations of greater than 15% plus or minus, within 150 milliseconds.
- A capability to respond to voltage perturbations on the supply side by carrying the load for a period greater than 15 seconds.

Status:

- Computer simulations, software development and documentation - 75%
- Laboratory Trials - 25%

Prototype and Demonstration of a light Emitting Diode (LED) Alternative to Screwbase Incandescent Lamps

EISG Grant Number: 01-03

PIER Area: Building End Use Efficiency

Principal Investigator: Kathryn Conway

Contact Information: Phone: (518) 331-7236,
email: options@ledconsulting.com

Organization: Conway & Silver, Energy Associated LLC

Grant Amount: \$74,850

Project Description: The purpose of this project is to research the feasibility of constructing a light-emitting diode lamp with a conventional screwbase and color control capability that could be used in existing incandescent light fixtures. The Contractor will specify and build engineering prototypes, based on U.S. Patent 6,149,283, issued on November 21, 2000, and titled, *LED Lamp with Reflector and Multicolor Adjuster*.

Proposed Outcomes:

- Fabricate 1 or more LED lamps as funds allow.
- A feasibility analysis based on the performance of the prototype lamps.
- Project objectives are to achieve a minimum 50% improvement in energy efficiency while maintaining light output within 20% of base case incandescent lamps.

Anticipated Benefits:

- LED lamps capable of achieving energy savings of 50% to 70% in light fixtures that would normally use incandescent lamps.

Status:

- Select Lighting Application for new Lamp - 80%
- Draft Specifications for prototype - 40%
- Issue bid for prototype services - 100%
- Select contractors and build lamp - 60%
- Develop and deliver test plan to EISG - 25%
- Issue request for quote for test services - 0%
- Select provider, then test the lamp - 0%
- Analyze test results compared to baseline - 10%

Materials For Fast-Response Solid Oxide Fuel Cells (SOFCs)**EISG Grant Number:** 01-04**PIER Area:** Environmentally Preferred Advanced Generation**Principal Investigator:** Lutgard DeJonghe**Contact Information:** Phone: (510) 486-6138email: dejonghe@lbl.gov**Organization:** University of California at Berkeley**Grant Amount:** \$74,997

Project Description: The purpose of this project is to research the feasibility of using a specially formulated composite anode layer on the thin ceramic electrolyte film in a SOFC. The anode layer will be low cost and tuned to the thermal expansion coefficient of the ceramic electrolyte film to permit rapid thermal cycling. Within the context of intermittently operating systems, is the capability of the fuel cells to withstand not only repeated thermal cycling, but also rapid heating as well. To date there is no satisfactory answer to reliability questions for SOFCs in intermittent distributed power scenarios. The basic problem is one of materials compatibility. The present work intends to remedy this problem by identifying and evaluating electrode materials that can support the thin film solid oxide electrolyte in the SOFC through conditions of rapid thermal cycling.

Proposed Outcomes:

- Prototype laboratory scale SOFC membranes constructed with composite anode layer.
- Feasibility analysis based on characterization and performance of prototype membranes to withstand rapid thermal cycling while maintaining a high power density (300 mW/cm²).

Anticipated Benefits:

- Increase the reliability of SOFCs used in distributed

generation applications by making them capable of rapidly cycling from room temperature to an operating temperature of 850°C.

- Reduce membrane cost to less than \$65/ft²

Status:

- Synthesis of starting Materials - 100%
- Characterization of starting materials - 100%
- Dilatometer studies on all materials - 100%
- SEM analysis of microstructure - 50%
- Fabrication of substrate - 100%
- Integration of Cr/YSZ layer with substrate - 100%
- Integration of Ni layer - 0%
- Application of YSZ film - 0%
- EDAX analysis of materials interaction - 0%
- Thermal cycling - 0%
- I-V and impedance testing of fuel cell structure - 0%

Gyroton Rotary Engine Project: A Controllably Variable Compression and Displacement Engine**EISG Grant Number:** 01-05**PIER Area:** Environmentally Preferred Advanced Generation**Principal Investigator:** Geoffrey Deane**Contact Information:** Phone: (805) 899-9199email: gdeane@gyroton.com**Organization:** Dehlsen Associates, LLC**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of constructing a rotary engine based on geometries that produce and follow an idealized, Asymmetric Complete-Expansion Cycle. The proposed engine design provides high thermodynamic and mechanical efficiencies, and a high power to weight ratio. Because it asymmetrically expands its working gases, the exhaust temperature and pressure are significantly lower than conventional designs, making it less acoustically and thermally obtrusive. The geometry allows dynamic control of both the engine's compression ratio and the engine's total displacement, allowing significant improvements to efficiency in various operating conditions, such as using varied fuels and operating under low engine load requirements.

Proposed Outcomes:

- A 10 HP prototype engine will be constructed
- Feasibility analysis based on the performance of the prototype engine.

Anticipated Benefits:

- Increase the fuel efficiency of internal combustion engines by improving the thermodynamic and mechanical efficiencies of the engine, which are needed to make IC engines competitive in the distributed generation market.
- Make available a more efficient IC engine with a capital cost around \$400/kW.

Status:

- Design - 20%
- Fabrication and Assembly - 1%
- Testing - 0%

Dual-Fired (Solar and Natural Gas) Generator for Use in a Space Cooling System for Residential and Light Commercial Buildings

EISG Grant Number: 01-06

PIER Area: Building End Use Efficiency

Principal Investigator: Michael Garrabrant

Contact Information: Phone: (740) 967-3006

email: mag@coolingtechnologies.com

Organization: Cooling Technologies Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of producing a dual-fired (solar thermal and gas) generator for a 5-refrigeration ton ammonia-water absorption chiller for use in space cooling systems for residential, multi-family, and light commercial buildings. The proposed commercial system consists of a concentrated, evacuated tube solar collector and an air-cooled absorption chiller specially designed to operate on either the thermal energy generated by the solar collectors or by natural gas or propane. This system differs from previous solar powered cooling systems in that it is:

- Small Size: targets the 3-25 Refrigeration Tons (RT) markets.
- Air-Cooled: air-cooling does not require expensive and difficult to maintain cooling towers.
- Dual-Fired: the system will be able to operate on either or both solar energy and natural gas or propane, an important feature for practical, affordable systems.

Concentrated, evacuated tube solar collectors capable of providing a 450° F supply temperature are currently commercially available. Successful completion of this project will allow solar panel manufacturers to integrate their products into a commercially available system.

Proposed Outcomes:

- A prototype dual-fired (solar-gas) generator for an absorption chiller.

- Feasibility analysis dual-fired design based on performance of prototype generator.

Anticipated Benefits:

- Reduce cooling energy cost up to 75% in a typical 2000 square foot home.
- Make available dual-fired systems in the 3-25 ton range.
- Solar thermal panels could be used for domestic hot water in the winter months when cooling is not needed.

Status:

- Design Alpha Dual-fired Generator - 100%
- Fabricate Dual-Fired Generator - 100%
- Design/Fabricate Hydronic Fluid Heating System - 100%
- Assemble Systems in Lab - 100%
- Testing - 100%
- Data Analysis - 75%
- Re-Test - 100%
- Design Beta Dual-fired Generator - 100%
- Fabricate Beta Generator - 100%
- Install Beta Generator in breadboard - 25%
- Test Beta Generator - 0%
- Data Analysis - 0%

Low Emissions Atmospheric Metering Separator (LEAMS)

EISG Grant Number: 01-07

PIER Area: Energy-Related Environmental Research

Principal Investigator: Doug Jung

Contact Information: Phone: (707) 523-4585,

email: two-phase@juno.com

Organization: Two-Phase Engineering & Research

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of a design change to reduce the noise level of the prototype LEAMS by 10-20 dB, thus resolving the main technical obstacle to commercialization. Additional design changes will be tested that will improve system performance and capacity. The separator is used for geothermal drilling, well-testing, power plant start-up and emergency venting use. The LEAMS is designed to be environmentally friendly, intrinsically safe and have multi-purpose use in the geothermal industry.

Proposed Outcomes:

- Modifications to the prototype will be fabricated and installed.
- Feasibility analysis based on performance testing of modified prototype.

Anticipated Benefits:

- LEAMS system has significant environmental advantages over the Blooie Muffler, which is currently used to control the emissions from geothermal well drilling.
- The Glass Mountain Geothermal Area in northern California may contain up to 500 Mw of geothermal power that cannot be recovered with existing technology due to regulatory requirements. It is anticipated that LEAMS will satisfy these regulatory requirements, making this valuable resource available to benefit California ratepayers.
- Reduces drilling and well-testing costs.
- Increases physical safety around the geothermal drill rig.

Status:

- Model System And Design Recycle Test Loop - 100%
- Design Noise Attenuation Recycle Header - 100%
- Design Secondary Abatement -100%
- Design Expansion Cell - 100%
- Design Atmospheric Dispersion Stack - 100%
- Fabrication Drawings Delivered To Drill Cool - 100%
- Install Recycle Loop (Drillcool) And Field Test - In Progress

Use of Waste Flue Gas to Reduce Biofouling of Power Plant Cooling Water Intakes**EISG Grant Number:** 01-08**PIER Area:** Energy-Related Environmental Research**Principal Investigator:** Greg Rau**Contact Information:** Phone: (925) 423-7990, email: ghrau@aol.com**Organization:** University of California at Santa Cruz**Grant Amount:** \$74,814

Project Description: The purpose of this project is to research the feasibility of injecting a small amount of flue gas from a gas-fired power plant in the cooling water intake to serve as an anti-biofouling agent for the power plant cooling water intake surfaces. The colonization of cooling water intakes by biota significantly impedes water flow, increases parasitic power requirement for pumping such water, and reduces cooling efficiency when biota become lodged in condenser tubing. The present prevention/remediation of this problem includes the periodic addition of bleach to the intake water, closed-cycle heating of the water, and plant shutdown to facilitate intake drainage and physical removal of biota from intake surfaces. Various other chemical additives and pipe coatings are being used in the power industry, but these are usually expensive, have limited lifetimes, and can have environmental impacts.

Significant reductions in the growth rate of marine biota of the

type that contribute significantly to biofouling are achieved by an increase in the concentration of a certain, otherwise innocuous seawater constituent. Since one source of this constituent is contained in flue gas from energy generation, it is suggested that the continuous addition of a small fraction of this byproduct into intake water could significantly reduce settling and growth of such organisms. If effective, such procedures would reduce or possibly eliminate the costly and potentially hazardous biofouling treatments currently employed. A series of on-site tests will be conducted at the Duke Energy's power plant at Moss Landing, California to determine the efficacy of such an approach.

Proposed Outcomes:

- A laboratory scale test rig will be constructed on site.
- Feasibility analysis based on the performance of the laboratory scale system.
- Optimized strategy for delivery and dosing levels.

Anticipated Benefits:

- Replace the costly and environmentally harmful biofouling treatments currently employed with the proposed system that would be lower cost and less harmful to the environment.
- An anti-biofouling agent that meets or exceeds all water quality regulations.

Status:

- Design experimental setup - 90%
- Construct experimental setup - 100%
- Record experimental data - 30%
- Analyze Results - 10%

Energy Efficient Municipal and Industrial Odor Control Equipment Study**EISG Grant Number:** 01-09**PIER Area:** Industry/Agricultural/Water End-Use Efficiency**Principal Investigator:** Bob Richardson**Contact Information:** Phone: (530) 474-4819 email: bob@prdd.net**Organization:** Pacific Rim Design & Development Inc.**Grant Amount:** \$74,982

Project Description: The purpose of this project is to research the feasibility of a new energy efficient process for eliminating odors at wastewater treatment facilities. The proposed process reduces the amount of energy used by blowers and compressors. Consulting engineering firms across the country have been and are still specifying wet scrubbers and carbon absorbers more frequently than any other waste-water

treatment and odor-control technology. Because this generation-old (30 years) technology employs large motors and is continuously operated in most facilities, it is a prime subject for energy-efficient design revision. These large energy users are necessary because the older wet scrubber technology had to move the foul air and either re-circulate large quantities of liquid, or make large volumes of compressed air for atomizing nozzles. The carbon absorbers use large quantities of energy to push the foul air through a granular material. This new technology utilizes a more effective oxidant and mixes it into the foul air stream with low-pressure nozzles.

Proposed Outcomes:

- A pilot scale odor control plant will be installed at a Pacific Rim test site.
- Feasibility analysis based on the performance of the pilot plant.
- Procedures for safe operation of the new equipment in the waste water treatment plant environment

Anticipated Benefits:

- Reduce by 40% the amount of electrical energy used in odor control equipment.
- Improve odor removal efficiency over conventional equipment.
- Elimination of the large scrubber vessel saving the cost of the vessel, the cost of maintenance of the vessel and recovering the space that such large vessels occupy.

Status:

- Prepare Test Protocol - 80%
- Design Pilot Equipment - 100%
- Procure Materials and build pilot equipment - 100%
- Procure/install instrumentation and controls - 100%
- Start up and testing of pilot equipment - 45%
- Test Pilot Odor control equipment - 20%
- Test other Odor control equipment - 0%

SOLICITATION 00-04

The Sagebien Project: A Rotating Fish Ladder that Generates Power and is Self Cleaning

EISG Grant Number: 00-24

PIER Area: Renewable Energy Technologies

Principal Investigator: Richard Ely

Organization: Davis Hydro

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of developing an undershoot water wheel modified to allow for fish passage. Turbines and their associated diversion dams form direct barriers to fish migration up and down stream causing mortality and morbidity of species that pass them. Common low head diversion dams are open channel flows. Water wheels allow fish to pass effortlessly down stream, but challenge fish moving upstream except during floods. One type of water wheel, the undershot breast wheel – and the Sagebien Wheel in particular – might be modified to allow fish to pass both ways and still efficiently generate hydropower.

Proposed Outcomes:

- Functional prototype of a modified water wheel to allow for fish passage
- Demonstrate that a useful amount of power can be generated from the given design

Anticipated Benefits:

- Fish friendly hydropower plant allowing upstream and downstream fish passage
- Easy adaptability to changing conditions
- Efficient power extraction

Project Status:

- Review wheel and fish passage parameters - 100%
- Review modifications to flume, fish testing - 100%
- Construct wheel and test cassette with brake -95%
- Initial power test – test for fish passage – 0%
- Review and Modify wheel as needed – 0%
- Final test and evaluation of fish passage – 0%

Development of a PEM Electrolyzer: Enabling Seasonal Storage of Renewable Energy

EISG Grant Number: 00-25

PIER Area: Renewable Energy Technologies

Principal Investigator: Peter Lehman

Organization: Humboldt State University Foundation, Schatz Energy Research Center

Grant Amount: \$74,478

Project Description:

The purpose of this project is to research the feasibility of developing a proton-exchange membrane (PEM) electrolyzer

capable of generating a minimum of three standard liters per minute of hydrogen at 2,000 pounds per inch² gauge pressure, using approximately one kilowatt of power. This is an important first step in the commercialization of high-pressure PEM technology.

Hydrogen can be produced using electrolyzers powered by renewable electricity, stored, and converted back to electrical energy as needed using a fuel cell. Hydrogen can be used as long-term, seasonal energy storage at reasonable cost, while other energy storage technologies including batteries, pumped hydroelectric storage, compressed air, flywheels, ultracapacitors, and superconducting magnets do not offer equitable storage capacity and cost that can be achieved with hydrogen. Hydrogen can be stored cryogenically as a liquid, chemically as a metal hydride or physically as a compressed gas.

Proposed Outcomes:

- Determine optimal current density and temperature
- Fabricate a prototype, proton exchange membrane electrolyzer with high-pressure hydrogen output

Anticipated Benefits:

- Eliminate the need for mechanical compression
- Reduce mechanical complexity of electrolyzers
- Reduce cost versus alkaline electrolyzers over a wide range of plant sizes
- Reduce maintenance needs versus current electrolyzers

Status:

- Perform Literature/Patent search. Determine state of the art in PEM -100%
- Prepare single PEM electrolysis cells for testing - 100%
- Bench test single cell design - 100%
- Redesign and retest single PEM electrolysis cell - 70%
- Design, fabricate and test a multi-cell PEM electrolysis stack - 25%

Field Validation of a Model of Generation and Migration of Methane and Other Gases in Landfills

EISG Grant Number: 00-26

PIER Area: Renewable Energy Technologies

Principal Investigator: Richard Prosser

Organization: GC Environmental, Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of field testing a simulator that will allow the user to predict and monitor the behavior of landfills. The

municipal solid waste (MSW) that is deposited in landfills undergoes anaerobic decomposition and produces a gaseous mixture called landfill gas (LFG), which consists mostly of methane and carbon dioxide (and some smaller amounts of oxygen and nitrogen) together with trace amounts of a number of volatile compounds (VOC). A typical landfill produces about 4-5 million standard cubic feet per day of LFG with larger landfills producing upwards of 50 million SCFD. Understanding how landfill gas is generated and migrates within landfills is of paramount importance to improve the collection efficiency of LFG without poisoning LFG generation by pulling air into the waste.

The use of LFG for generating electricity is a promising approach both in terms of conserving energy and also for reducing air pollution while producing electricity since the VOC in LFG are burned in the combustion chamber. LFG has the potential of becoming an abundant and stable renewable source of energy for California and the nation. The challenge that exists is to collect all the gas that is produced in the landfills, and not allow it to be inadvertently lost to the atmosphere as fugitive emissions. This project will help optimize landfill gas collection and utilization systems for energy production.

Proposed Outcomes:

- Develop a validated simulator that can predict the rate of gas generation and migration, flow of the leachates, the composition of the gas and air on top surface of the landfill and in the surrounding soil, and the pressure build-up in the landfill
- Help increase the understanding of dynamic subsurface behavior in relation to environmental and physical process changes

Anticipated Benefits:

- Reduce landfill gas emissions, which will decrease air pollution and increase LFG power plant generating potential.
- Increase the captured amount of useful landfill gas for power generation
- Reduce landfill gas power plant costs by increasing efficiency

Status:

- Collect field data from site in Kern County, California - 75%
- Set Up Model Simulation - 75%
- Analyze results of model simulation - 50%
- Collect additional data as needed and re-evaluate model - 0%
- Implement and improve landfill gas system design - 0%

Simple and Reliable Active Power Filter for Energy Efficiency and Power Quality

EISG Grant Number: 00-27

PIER Area: Industrial/Agriculture/Water End-Use Efficiency
Principal Investigator: Keyue Smedley (949) 856-1742
Organization: University of California, Irvine
Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of developing a fast, active power filter capable of responding within one-cycle of the frequency to cancel the harmonic and reactive current generated by the nonlinear loads of electrical transmission systems and to ensure a clean sinusoidal current draw from the power line. The utility grid provides sinusoidal voltage for a variety of users. Most of the loads in industry, commercial, agriculture, and residential applications are electronic appliances and motor drive systems, which draw capacitive and inductive currents from the grid. These loads are highly nonlinear and they inject harmonic and reactive current to the grid, resulting in low power factor, low transmission efficiency, and harmful disturbance to other appliances. One-cycle control eliminates the multipliers, the current reference calculator, and voltage sensors, which are required in the control loop of prior systems. The design requires fewer components resulting in lower cost while maintaining performance and reliability.

Proposed Outcomes:

- Develop functional prototype
- Develop design guidelines
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Improve power transmission efficiency by 30%
- Improve power quality (current distortion <5% THD – total harmonic distortion)
- Increase reliability
- Reduce system costs due to simplified design
- Help eliminate harmful line disturbances that can damage appliances

Status:

- Perform steady state analysis and design - 100%
- Perform dynamic analysis for stable operation - 100%
- Circuit construction - 95%
- Circuit debugging and optimization - 80%
- Develop Test Plan and deliver to EISG for approval - 100%
- Conduct Performance tests on Prototype power filter - 30%

OTM Aided Oxygen Enhanced Combustion

EISG Grant Number: 00-29

PIER Area: Environmentally Preferred Advanced Generation
Principal Investigator: Theodore Tsotsis
Organization: University of Southern California
Grant Amount: \$75,000

Project Description: The purpose of this project is 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. The use of an O₂-enriched oxidizer in natural gas combustion stems either from the requirement to achieve high temperatures in industrial furnaces and boilers (with either low, e.g. 21-30%, or high, e.g. 80-95%, O₂ -enrichments being of practical interest), or the need to enhance flame stability under fuel-lean burning conditions in gas turbines. OEC is a potential solution in the latter application, because increasing the O₂ content allows more stable burning, while maintaining the same flame temperature, an important consideration, since flame temperature is a good measure of the combustion device's energetic output. Furthermore, for the same flame temperature, O₂ -enrichment offers the additional advantage of lower NO_x production due to the reduced N₂ content. OEC also shows promise in power generation for staged combustion with the O₂ -enriched oxidizer involved in one of the stages.

Other OEC beneficial effects include:

- Increased radiative heat transfer rates;
- Enhanced power output and thermal efficiency; and
- Significant reduction in flue-gas volume.

OEC flue-gas contains higher CO₂ levels, which gives an important advantage if CO₂ capture/recovery ever becomes an issue. Taken together these benefits give OEC an excellent long-term potential for expanded power generation applications.

Proposed Outcomes:

- Subscale prototype system
- Feasibility analysis based on prototype performance
- Better understanding of combustion process

Anticipated Benefits:

- Increased thermal efficiency and improved flame stability
- Lower NO_x due to lean premixing
- Reduced flue gas volume

Status:

- Selection and Characterization of OTM - 90%
- OEC Experimental Studies - 90%
- OEC modeling Studies - 90%
- Stability Characteristics of OTM - 70%

Low Cost Hybrid Inverters Utilizing IGBTs and SCRs

EISG Grant Number: 00-30

PIER Area: Industrial/Agriculture/Water End Use Efficiency

Principal Investigator: Giri Venkataramanan

Organization: University of Wisconsin-Madison

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of developing a low-cost hybrid inverter/converter utilizing SCRs and IGBTs that could be used in variable speed drives and distributed generation systems such as photovoltaics (PV) and wind turbines. The project is aimed at reducing the cost and improving the reliability of inverters used in high power adjustable speed drives and distributed power generation systems.

Power inverters, used to convert electricity from dc to ac, constitute an enabling technology in a wide range of advanced electrical energy applications. Their application in adjustable speed motor drives continues to transform several industrial processes resulting in dramatic performance and efficiency improvements. Any reduction in inverter cost will result in broadening their application and lead to further improvements in energy efficiency. Inverters also form an integral part of modern distributed utility-grade power generation systems such as photovoltaic systems, wind energy systems, fuel cells and micro-turbine systems. These applications also stand to gain from reduced costs of inverters. The proposed inverters will realize higher reliability, lower cost and higher performance when compared to conventional pulse width modulated inverters using IGBTs or line-commutated inverters using SCRs respectively.

Proposed Outcomes:

- Developed computer simulation based on existing models
- Design and built circuit
- Quantification of performance based on working design

Anticipated Benefits:

- May reduce converter/inverter costs by up to 75%
- Increased reliability
- Potential increase in performance output
- May eliminate poor input power quality

Status:

- Characterization of SCR/IGBT Active Communications - 100%
- Power Circuit Design - 100%
- DSP Controller Design - 80%

- Hardware Fabrication - 75%
- Assembly and Testing - 30%

Advanced Generation of H₂ and CO from Improved Methane-Carbon Dioxide-Steam Reforming Process, for use as Fuel and Methanol, Gasoline Synthesis Gas

EISG Grant Number: 00-32

PIER Area: Strategic Energy Research

Principal Investigator: Zoe Ziaka

Organization: Individual

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of using a catalysis reaction to convert waste gas streams containing CO₂ and methane to CO and hydrogen, of which the hydrogen could be used to power fuel cells. This technology will utilize and upgrade CO₂-containing methane streams such as landfill, sour, and waste type gases. CO₂-innovative abatement processes, especially within in-situ reactors via relevant reactions and catalysis systems is under increased consideration in current and future industrial efforts, and is considered an additional benefit of this proposed work. This project will develop a new, effective reforming and catalysis system that converts the above feedstocks and delivers purified grade gas required for fuel cell applications.

Proposed Outcomes:

- Developed selective catalyst
- Production of synthesis gas from reforming of secondary and waste hydrocarbon streams
- Completed evaluation of the process for integration to turbines, fuel cells or synthesis gas

Anticipated Benefits:

- Increased production of Hydrogen
- Projected energy savings in the range of 20-30%
- Abatement of CO₂ mixtures, which lowers greenhouse gas emissions

Status:

- Design and model the process - 85%
- Simulate the Hydrocarbon conversion reactor (reformer) - 80%
- Run Model while simulating various conditions in the reactor - 80%
- Improve the reactor conditions and fuel cell operation - 80%
- Simulate and evaluate combined hydrocarbon reactor to fuel cell and methanol reactor operation - 80%

Improved Insulation for Buildings and Refrigeration

EISG Grant Number: 00-33

PIER Area: Building End Use Efficiency

Principal Investigator: Jeffrey Zucker

Organization: Individual

Grant Amount: \$74,525

Project Description: The purpose of this project is 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. In the construction and refrigeration industries, insulation values are currently limited to a maximum R factor of 10 per inch. This R-value of 10 is for black Glasscell material that is rarely used. The most common materials have R-factors of from 2.5 to 8. Therefore, in order to achieve high levels of insulation, a structure must have relatively thick and expensive walls to have a high-wall, thermal insulation value.

The proposed improvement to building and refrigeration insulation is a lightweight ceramic insulation made of low-cost, readily available materials. Research shows that a ceramic insulation made with perlite and other materials can produce an insulating material with an R factor of up to 40. Perlite-based ceramic insulators have unique properties that make them

suitable for building and refrigeration applications. To make the product applicable for most insulating situations, the product should be hydrophobic, should be easy to manufacture, and needs certain mechanical properties to make it marketable.

Proposed Outcomes:

- Produce a high-efficiency ceramic thermal insulating material made from low cost materials
- Produce a product that can be cast or molded into sheets or other desirable shapes

Anticipated Benefits:

- Insulation material with an R value of up to 40
- Ceramic insulation having sufficient mechanical strength to be self-supporting and easy to handle
- Provide leads to improving energy efficiency in buildings and refrigeration systems

Status:

- Locate and equip shop space - 90%
- Fabricate Samples - 80%
- Conduct "In-Shop" Performance tests on samples seeking high quality - Ongoing
- Send selected samples to Independent Lab for R-factor testing 0%

SOLICITATION 00-03 AWARDS

Controlling Fouling with Rice Straw Blends in Biomass Boilers

EISG Grant Number: 00-20

PIER Area: Renewable Energy Technologies

Principal Investigator: Charles E. Leshner

Organization: UC Davis

Grant Amount: \$73,858

Project Description: The purpose of this project is to research the feasibility of developing a test plan that will determine the allowable additions of rice straw to wood-based fuels in order to minimize alkali volatilization and thus to restrict fouling potential. The California biomass power industry is facing increasing environmental and economic pressures to utilize herbaceous fuels, such as rice straw. These fuels are expected to increase the potential for slag deposition and fouling of heat exchangers that lead to a reduction in the efficiency of biomass power generation and to an increase in operating costs. However, new experimental results show that the addition of rice straw to conventional biomass fuel types can reduce alkali volatilization.

The test plan will determine the allowable additions of rice straw to wood-based fuels in order to minimize alkali volatilization and thus restrict fouling potential. The fusion temperatures and rates of potassium volatilization of slag formed from blends of rice straw and wood ashes will be established. These data will be used to formulate predictive models for the high-temperature fouling potential, the physical properties, and tenacity of slag deposits from fuel blends. From the results, practical predictions regarding tolerable fuel blends and proposed new combustion strategies utilizing unconventional and lower cost blends of herbaceous and conventional wood fuels will be proposed. These predictions will be tested in a fluidized bed combustor.

Proposed Outcomes:

- Quantify fouling potential of rice straw fuel blends
- Determine optimal rice straw fuel blends for reducing fouling
- Demonstrate that a minimum addition of 10% rice straw can be accomplished without a
- proportional increase in fouling rate

Anticipated Benefits:

- Increased fuel flexibility for fluidized bed combustor
- Reduced maintenance costs

Status:

- Installation of melting furnace - 100%
- Selection and preparation of test ashes - 100%
- Develop and Deliver test plan to EISG Program Administrator - 100%
- Melting of rice straw ash - 100%
- Melting of wood ash - 100%
- Melting of ash blends - 100%
- Instrumental analyses of products - 100%
- Evaluation of results Selection of ash Blend for further testing - 100%
- Fluidized bed combustion of selected fuel blends - 10%

Application Feasibility Study of Gravitational Non-equilibrium Heat Pumps and Heat Engines**EISG Grant Number:** 00-21**PIER Area:** Environmentally Preferred Advanced Generation**Principal Investigator:** Thomas C.B. Smith**Organization:** Individual**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of developing a gravitational heat engine (GHE) where the fundamental operating principle is entirely dependent on at least part of the system never reaching equilibrium. The Gravitational Heat Engine is a Rankine cycle with one moving part. A comprehensive understanding of GHE properties for the purposes of engineering applications does not yet exist. This project will concentrate on investigating the feasibility of GHEs for electricity generation as a cogenerative engine for extracting energy from any low-grade heat source.

Proposed Outcomes:

- Construct functional prototype
- Demonstrate system efficiency of between 2 and 10% converting solar energy to electricity
- Heat engine fueled by solar and low temperature waste heat
- Feasibility analysis based on performance of functional prototype

Anticipated Benefits:

- Unit production cost range of \$1500-\$7500 per kW for electricity production
- Unit production cost range of \$40-\$160 per kW for heating

Status:

- Construction of Test rig with test Hardware and Interfaces - 100%
- Construction and characterization of expander assembly - 100%
- Qualitative performance checks - 100%
- Quantified adaptation (Optimization) - 0%
- Alteration of apparatus for comparison - 0%
- Comparison of conventional cycles - 0%
- Selection and integration of a commercial solar collector - 80%
- Adaptation of expander and condenser - 100%
- Optimization of system efficiency - 0%

An Innovative Approach to Stabilize the Thermal Conductivity of Air Plasma-Sprayed Thermal Barrier Coatings**EISG Grant Number:** 00-22**PIER Area:** Environmentally Preferred Advanced Generation**Principal Investigator:** Rodney Trice (765) 494-6405**Organization:** Purdue University**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of increasing the overall efficiency of land-based turbines via an innovative materials solution employing micro-structurally designed thermal barrier coatings (TBCs). Sintering (i.e. densification of the coating) causes the thermal conductivity of thermal barrier coatings to increase by as much as 100-150% during service, greatly reducing the ability of the thermal coating to protect the underlying structure from temperature extremes. For example, the thermal conductivity of an air plasma-sprayed coating will increase from 1.2 W/m-K to 2.3 W/m-K after 50 hours exposure to 1200°C (2192° F) heat. The end result of an increase in the thermal conductivity of the coating is that the gas turbine must be operated at lower temperatures or more cooling must be provided for the hot components. Either of these results decreases the efficiency of the electricity production.

To inhibit sintering, the coating will be altered at the atomic level by changing the chemical properties of the TBC via the addition of select dopants. The basic mechanism for inhibiting sintering is based on the "Space Charge Theory". This theory predicts that added dopants will tend to segregate to grain boundaries to keep the crystal electrically neutral. The effect of the cations (positively charged ions) accumulating at the grain boundaries is to prohibit boundary movement, a necessary

condition to keep sintering from occurring. The result is that the microstructure that gives rise to the low thermal conductivity is stable because sintering of the coating is prohibited. The goal is a 100% reduction in the long-term thermal conductivity of these microstructurally designed coatings

Proposed Outcomes:

- Produce a thermal barrier coating capable of maintaining a thermal conductivity of 1.2 W/m- K over 500 hrs at 1400°C (2552° F)
- Produce colloidal suspensions of 1-mm diameter stabilized zirconia and dopants that can be
 - plasma sprayed without agglomeration
- Optimize the plasma-spray parameters for each stabilized zirconia/dopant to satisfy the following criteria: (a) a high degree of atomic mixing occurs, (b) 1 mm deposition rates are observed, and (c) coatings contain less than 15% porosity
- Reduce the amount of sintering that occurs in the coatings by reducing grain growth by 100%

Anticipated Benefits:

- Increase of combustion temperature by 50°C (122° F)
- An increase in efficiency of 3-4%
- Increased reliability of the coating

Status:

- Microstructurally Design Coatings - 100%
- Investigate Potential Dopants - 100%
- Prepare Colloidal Suspensions - 100%
- Fabricate Coatings - 80%
- Develop Optimum Processing Parameters - 90%
- Plasma Spray Coatings for Evaluation - 50%
- Characterize Coatings - 10%
- Evaluate Thermal Conductivity - 0%
- Evaluate Dilatometry Response - 0%
- Compare Doped Coatings with Baseline - 0%

SOLICITATION 00-02 AWARDS

Research on Manufacturing Quadruple-Junction Solar Cells

EISG Grant Number: 00-14

PIER Area: Renewable Energy Technologies

Principal Investigator: Robert Hicks (310) 825-8891

Organization: UC Los Angeles

Grant Amount: \$74,268

Project Description: The purpose of this project is to research the feasibility of increasing the conversion efficiency of quadruple-junction solar cells by optimizing the chemical vapor deposition process. Quadruple-junction solar cells show great potential for achieving terrestrial conversion efficiencies above 40%. At these levels, the photovoltaic devices could be competitive for large-scale electric power generation. Quadruple-junction solar cells consist of epitaxial thin films of indium, gallium phosphide (In_{0.48}Ga_{0.52}P), gallium arsenide and indium gallium arsenic nitride (In_{0.09}Ga_{0.91}As_{0.97}NO_{0.03}) lattice-matched to germanium substrates. A sophisticated chemical process known as metalorganic chemical vapor deposition (MOCVD) produces these materials.

The objective of this project is to identify the MOCVD process conditions crucial to the development of a robust manufacturing technology. This technology must be capable of

producing defect-free films with sharp interfaces and precise composition profiles. The atomic and microscopic structures produced by MOCVD will be characterized by scanning tunneling microscopy, x-ray photoemission, spectroscopy, high-resolution x-ray diffraction, photoluminescence, and current-voltage measurements. New deposition process will be developed and examined for the fabrication of quadruple-junction solar cells with light conversion efficiencies exceeding 40 percent.

Proposed Outcomes:

- Methodology for vapor deposition process that yields precise smooth layers with sharp interfaces between layers
- Feasibility analysis based on performance of fabricated test samples

Anticipated Benefits:

- Solar power production at a cost of \$.03-\$.04 kWh
- Achieve solar cell conversion efficiency over 40%

Project Status:

- Grow InGaAsN on GaAs (001) substrate by MOCVD - 70%
- Deposit InGaP on GaAs with abrupt interface - 100%
- Engineer quadruple-junction solar cells by MOCVD - 0%

Evaluation of a New Solar Air-Conditioning System

EISG Grant Number: 00-16

PIER Area: Building End Use Technologies

Principal Investigator: William Kopko (703) 323-9578

Organization: WorkSmart Energy Enterprises, Inc.

Grant Amount: \$74,546.60

Project Description: The purpose of this project is to research the feasibility of a solar air-conditioning system that combines a liquid desiccant-based cooler and a low-cost solar collector for regenerating the liquid desiccant. The project will build and test a bench-scale prototype for evaluating a new solar air-conditioning system. The new system combines a desiccant-based cooler and a low-cost solar collector. In addition the system provides low-cost energy storage, which allows the use of off-peak electricity for backup during extended cloudy periods. The project will involve testing heat-exchanger components, building a prototype cooler, measuring the performance of the cooler, building and testing a small solar collector, assembling and testing a complete bench-scale solar air conditioner, and summarizing the results in a final report. Successful completion of this project will obtain basic component performance data and demonstrate a working bench-scale solar air conditioning system.

Proposed Outcomes:

- Subscale prototype system
- Feasibility analysis based on prototype performance

Anticipated Benefits:

- Reduce AC power consumption by 80% compared to conventional air conditioning
- Competitive installed costs to conventional AC systems

Project Status:

- Test cooler components 100%
- Build bench-scale cooler 80%
- Test cooler 0%
- Build and test solar collector 100%
- Assemble and test complete system 0%

Commercial and Residential Super Insulated Phase Change Material Water Heater

EISG Grant Number: 00-18

PIER Area: Building End Use

Principal Investigator: Nick Wynne (937) 376-8233

Organization: VacuPanel Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of developing an innovative electric water heater that increases operating efficiency by incorporating vacuum insulation and phase change materials. This will be accomplished by means of an innovative, advanced technology water heater design which uses the advantages provided by vacuum insulation panel (VIP), and phase change material (PCM) technologies to reduce the operating expense and improve the efficiency of maintaining heated water. Energy stored in heated water statically awaits demand throughout the day, and is frequently wasted due to stand-by losses.

The proposed water heater will be designed to optimize the storage of heat in a phase change material (PCM), through which cold water passes to become heated, use VIP to retain the heat in the PCM over a long period and be recharged (heated to change phase) at less expensive, off-peak electricity or natural gas. Such a heater will provide more efficient and lower cost hot water. The operating cost is reduced through off-peak energy savings, reduced stand-by energy losses, and long life.

Proposed Outcomes:

- Full scale prototype hot water heater
- Feasibility analysis based on performance of prototype system

Anticipated Benefits:

- Increase the average water heater life from 7 years to 50 years
- Increase water heater efficiency by 6% by reducing standby losses
- Provide increased ability to shift energy consumption to off-peak hours

Project Status:

- Review cost, availability, characteristics of PCM 100%
- Review Heat Exchanger and submersible pump options 90%
- Evaluate effectiveness of vacuum panel insulation 85%
- Evaluate techniques for circular seals in Vacuum panel insulation 100%
- Evaluate improved design, manufacturability of cylindrical vacuum panel insulation 85%
- Develop Options for installing thermal breaks on water heater protrusions 100%
- Benchmark PCM/Heat exchanger combinations 70%
- Build prototype 0%
- Test Prototype 0%

SOLICITATION 00-01

AGF Pasteurization Process Assessment, Orange County, CA

EISG Grant Number: 00-03

PIER Area: Renewable Energy Technology

Principal Investigator: Dennis Burke (360) 923-2000

Organization: Cyclus EnviroSystems

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of a pilot plant using an anoxic gas flotation pasteurization process to more efficiently convert organic materials such as agricultural waste, sewage sludge, and manure into fuel gas and Class A residual solids. The innovative process can use the heat recovered from power generation to increase the quantity of organic material converted to gas while producing disinfected nutrient rich, residual. More gas is produced, fewer residual solids must be disposed, and public health is protected while the capital and operating costs of waste treatment and power generation is reduced.

The biochemical process is the anoxic gas flotation (AGF) pasteurization process that utilizes high temperature waste heat from a turbine, microturbine, or engine generator set to increase the rate and quantity of organic material converted to gas. A 40% improvement in solids converted to gas has been shown at laboratory bench scale. The AGF pasteurization process also reduces the amount of process energy required when compared to conventional or thermophilic digestion processes and the quantity of the concentrated, nutrient rich, residual product to be disposed. The disinfected residual product can be given or sold to the general public, locally, without restriction.

Proposed Outcomes:

- Pilot plant capable of processing 400 gpd of sewage sludge.
- Optimized methodology for operating processing plant.
- Feasibility analysis based on pilot plant performance.

Anticipated Benefits:

- Up to 40% increase in conversion rate of organic solids to biogas.
- Increase fuel gas production by 25%
- Reduce solids processing costs by 60%.
- Produce a disinfected Class A residual product that does not require landfill disposal.

Project Status:

- Design 100%
- Pilot Plant Construction 100%

- Start-up and initial operation 80%
- Monitoring and Analysis of Process 50%
- Evaluation of process performance 0%

Carbon Foam Based NO_x Biofilter

EISG Grant Number: 00-04

PIER Area: Energy-Related Environmental Research

Principal Investigator: Daniel Chang (530) 752-2537

Organization: UC Davis (UCD)

Grant Amount: \$74,989

Project Description: The purpose of this project is to research the feasibility of using Ultramet carbon foam as a packing material in a post combustion NO_x biofilter to increase efficiency and reduce capital cost. However, biofiltration to control NO_x is difficult because of mass transfer rate limitations. Newly engineered materials developed for other applications, e.g., Ultramet carbon foam for catalyst supports, can be tailored to meet the needs of an inexpensive, light weight, inert, biofilter packing that provides a high specific surface area (surface-to-volume) to greatly increase the mass transfer rate. UCD believes that the key to economical biological treatment of NO is to maximize the specific surface that can support the necessary biofilm without clogging. The objective of this work is to conduct energy-related environmental research that demonstrates the feasibility of developing a commercially viable NO_x biofilter.

Proposed Outcomes:

- Subscale prototype biofilters.
- Design parameters for system scale up.
- Feasibility analysis based on performance of prototype biofilters.

Anticipated Benefits:

- Reduce the cost of NO_x removal by at least 50% to \$0.40/lb-NO_x
- Provide cost effective means of lowering emissions from small-distributed generation units.

Project Status:

- Construct lab-scale biofilters 100%
- Verify that NO₂ is also oxidized 75%
- Vary column operating conditions 25%
- Construct lab-scale filters 90%
- Perform Literature search for background information to interpret obtained data - 100%

SOLICITATION 99-04

Cost Effective, Low Distortion, Adjustable Speed Drives(ASDs)

EISG Grant Number: 99-34

PIER Area: Industrial/Agriculture/Water-End-Use Efficiency

Project Manager: Arthur Iversen (408) 354-7972

Principal Investigator: George Gabor (925) 284-9529

Organization: Spinel LLC.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of a new, low cost, pulse width modulated (PWM) inverter design capable of producing pure waveforms for controlling adjustable speed drive (ASD) motors. The focus of the project is to establish the feasibility of building adjustable speed drives that do not produce the distorted waveforms that cause premature motor failures such as those generated by the ASDs now in use. Electric motors are designed to run on sinusoidal utility power (60 Hz). An advanced ASD, employing high frequency switching >60kHz, allows the synthesis of essentially pure sine waves that are cleaner than those received from the Utility and provides normal motor life. Agricultural uses of ASD motors include programmed pump irrigation, and uses in produce conveyers and processing systems. ASD pumps are used to control water flow in water transport and sewage treatment plants.

Proposed Outcomes:

- A prototype motor controller will be fabricated and tested on a three-phase 5 HP motor.
- Prototype three-phase inverter capable of producing pure variable frequency sine waves with current harmonics less than 5% and efficiency greater than 92% regardless of cable length.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Low cost solution to eliminating premature ASD motor failures due to leading edge PWM pulse spikes which cause premature insulation failure.
- Eliminate or minimize costly harmonic filters and associated engineering analysis that is currently required for harmonic sensitive ASD installations.
- Significantly increase ASD market penetration which is currently only 9% due to lack of confidence in the technology

Project Status:

- 10 kW high frequency, low harmonic AC-DC converter - Design - 95%

- Construction & debugging -20%
- Demonstrate - 100%
- 10kW single phase (one leg of three phase)
- Design - 0%
- Construction & debugging - 0%
- Interface with converter - 0%
- Test and operation - 0%

Development of a Borehole Seismic Receiver Array for Geothermal Wells

EISG Grant Number: 99-37

PIER Area: Renewable Energy Technologies

Principal Investigator: Bjorn Paulsson (562) 694-9598

Organization: Paulsson Geophysical Services, Inc.

Project Description: The purpose of this project is to research the feasibility of developing a borehole seismic receiver array for geothermal wells capable of operating in a temperature range of 200°-250°C. Existing short and low temperature arrays severely limit the use of borehole seismology in geothermal energy exploration. This project will address this shortcoming by developing a much larger seismic receiver array that can operate at much higher temperatures.

Large borehole seismic receiver array technology will make it possible to routinely map high permeability zones and monitor production in fractured geothermal reservoirs with a resolution in the range of 3 to 6 ft (1 - 2 m) using 3D VSP, passive seismic monitoring and cross well seismic techniques. Three component arrays allow recording of both P and S wave data that together provide information on the location, the size and the preferred direction of fractures and fracture zones in the reservoir. The fracture information is the key information that will help determine the directional permeability of the reservoir and how to economically produce its geothermal resources.

Proposed Outcomes:

- Cable design capable of withstanding operational temperatures of 200°–250°C.
- A prototype five-level high-temperature borehole seismic receiver array.
- Feasibility assessment based on prototype performance testing in field setting.

Anticipated Benefits:

- Ability to record P and S wave data that enable the mapping of fracture zones in high-temperature geothermal reservoirs.

- Enable more efficient management of existing geothermal reservoirs.
- Reduce the number of wells needed to develop a geothermal resource.
- Allow economic development of lower temperature and lower permeability geothermal fields.

Project Status:

Project term has been extended due to delay in manufacturing of High Temperature Cable to project specification

- Design 75%
- Vendor Selection 50%
- Manufacturing 10%
- Environmental testing of components 0%
- Field testing of completed assembly 0%
- Processing of recorded data 0%



SOLICITATION 00-04

An Integrated Anti-Fouling Technology for Energy Efficient Chillers

EISG Grant Number: 00-23

PIER Area: Building End Use Efficiency

Principal Investigator: Young Cho

Organization: J&D Thermo-Fluid Technology, Inc.

Grant Amount: \$74,953

Project Description: The purpose of this project is to research the feasibility of developing a solenoid-induced precipitation and side-stream filtration for chillers, which will cause excess mineral ions to precipitate out thus reducing scaling of chillers and raising their efficiencies. The electricity consumed by medium to large size chillers (200 – 2,000 tons) is a major portion of total electric consumption in California and worldwide. These chillers are often water cooled, and fouling in chiller tubes (or more specifically condenser tubes) decreases chiller efficiency, thereby substantially increasing the consumption of electricity, particularly during the cooling season. Integrated anti-fouling (IAF) technology can prevent or mitigate fouling in condenser tubes enabling chillers to run more efficiently during the entire cooling season. This will result in substantial and continuous savings in electricity. Another major benefit of the IAF technology is the substantial reduction of peak electricity demand levels generated by space cooling systems during the hottest days of the year.

The IAF technology uses solenoid-induced precipitation and side-stream filtration. Solenoid-induced precipitation utilizes a square-wave pulsing current to create time-varying magnetic fields, which in turn produce an induced pulsating electric field in the circulating water. Excess mineral ions such as calcium and magnesium in cooling-tower water precipitate out as mineral salts, providing nucleation sites for other dissolved mineral ions. As the cooling-tower water is continuously circulated, the precipitated seed crystals grow into larger particles, which are then removed by side-stream filtration. When the scale-causing mineral ions are removed from the cooling-tower water, fouling at the condenser tubes can be prevented or significantly mitigated, resulting in direct electricity savings.

Proposed Outcomes:

- Develop anti-fouling technology for medium-to-large chiller applications
- Demonstrate feasibility of the technology

Anticipated Benefits:

- Increased water savings

- Increased electrical savings
- Reduced peak electricity demand

Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress.

Method of Improving Efficiency of Combined Cycle Power Plants

EISG Grant Number: 00-28

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Robert Surette

Organization: Energy Constructs

Grant Amount: \$63,500

Project Description: The purpose of this project is 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. Turbine exhaust backpressure is a significant source of efficiency loss in gas-turbine fired power plants. Dynamic pressure recovery in turbine exhaust nozzles is limited by the onset of flow separation at an area ratio of the order of 1.5:1. By adding an Ejector-Diffuser (Patent No. 5,632,142), the total expansion ratio can be doubled without flow separation.

Additionally, the ejector provides a source of suction that can be used to modify the boundary layer separation experienced in the transition section of the heat recovery steam generator. This will allow a much more uniform flow distribution into the heat exchangers with fewer mechanical attenuation devices such as perforated plates, which are a major source of pressure loss. The added pressure recovery will manifest itself in a reduction in turbine exhaust backpressure that directly translates into an increase in power at the same fuel consumption or lesser fuel consumption at the same power output.

Proposed Outcomes:

- Computational Fluid Dynamics model
- Quantify pressure recovery potential
- Demonstrate potential for stabilizing the boundary layer in the transition layer

Anticipated Benefits

- Potentially increase of energy by a half of one percent
- Easy retrofit design
- Potential payback of 2-3 years

Status:

- 100% Complete on schedule and within budget
- Final Draft Report completed - in technical review
- Feasibility Analysis Report - Analysis in progress

Polymer-Zeolite Nanocomposite High-Temperature Proton-Exchange-Membranes for Fuel Cells

EISG Grant Number: 00-31

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Yushan Yan

Organization: University of California, Riverside

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of developing a novel, polymer zeolite nanocomposite proton-exchange-membrane (PEM) to allow a PEM fuel cell to operate at high temperatures with comparable or superior performance to that of a bare Nafion PEM fuel cell operated at 80°C. Current Nafion-based PEM fuel cell systems still face significant technology roadblocks that have to be overcome before the technology can become commercially viable. These technology roadblocks include:

- water management at the electrodes;
- CO poisoning of the anode catalyst;
- slow cathode kinetics; and
- high cost of the electrode catalyst.

It has been demonstrated that these problems will be eliminated once the operating temperature is increased to above 100°C.

Recently, hydrophilic silica nanoparticles have been incorporated into Nafion membrane to help maintain hydration at high temperatures with promising results. But the cell performance of these silica-containing membranes is still inferior to the bare Nafion operated at 80 °C. Although hydrophilic, silica particles are not proton conductors. Clearly, a material that is not only hydrophilic but also a good proton conductor is preferred. Zeolites are such materials. Zeolites are a class of crystalline aluminosilicates with uniform pores and cavities. First, aluminosilicate zeolites are hydrophilic. Because of zeolites' microporosity (<20 Å), zeolites can maintain hydration at very low relative humidity. Aluminosilicate zeolites are also proton conductors. Therefore zeolites are expected to be a much better material than silica for the application.

Proposed Outcomes:

- Synthesized zeolite nanocrystals
- Produce a nano-composite proton-exchange-membrane (PEM) that will operate at high temperatures (110-115° C)

Anticipated Benefits:

- Increase working temperature by 30-35° C.
- Reduce problems associated with CO poisoning of the anode catalyst
- Reduce PEM operating costs

Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress

SOLICITATION 00-03 AWARDS

A PCM Slurry System to Decrease Peak Air Conditioning Loads

EISG Grant Number: 00-19

PIER Area: Building End-Use Efficiency

Principal Investigator: Randy Clarksean

Organization: Leading Technology Designs, Inc.

Grant Amount: \$73,457

Project Description: The purpose of this project is to research the feasibility of developing a phase change slurry (PCM) mixture to be used in an air conditioning (a/c) unit to absorb peak a/c loads. The slurry is a mixture of water, emulsifier, and paraffin. The innovations pursued here are the development of a high concentration PCM Slurry and the development of a low-cost system to absorb A/C loads and to reject that energy to the earth. The project goal is to produce stable, high-volume fraction PCM slurry and demonstrate that this slurry can be pumped through a heat exchanger and stored.

Proposed Outcomes:

- Develop and demonstrate a PCM slurry mixture capable of absorbing 30% or greater of the peak A/C load
- Fabricate bench-scale PCM system and perform system tests

Anticipated Benefits:

- A system capable of reducing a/c loads by 30% or more.
- A unit with a production cost range of \$40-\$160 per kW for heating.

Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress.

SOLICITATION 00-02 AWARDS

Energy-Efficient Designs for Swimming Pool Pump Systems

EISG Grant Number: 00-08

PIER Area: Building End Use

Principal Investigator: Taghi Alereza (916) 363-8383

Organization: ADM Associates, Inc.

Grant Amount: \$74,691

Project Description: The purpose of this project is to research the feasibility of reducing the flow rate of the filter pumps on commercial and educational swimming pools while maintaining the required water quality. In educational and commercial facilities with swimming pools, it is often standard practice to run the pumps for the pool filtration system continuously at the design flow rate. Although engineering calculations show that it is reasonable to reduce the flow rate for a pool filtration system below the design flow rate, an important barrier to making this energy saving change is a concern about water quality and health problems. Health standards generally require that a minimum flow rate be maintained for public pools.

Filtering slowly makes for better filtering. However, it has been standard practice to design the filtration system for an

educational or commercial facility with a swimming pool with a single pump that runs continuously at the design flow rate. Because swimming pools in educational and commercial facilities are generally not open 24 hours a day, there is room to reduce the flow rate of the filtration system pump during those hours when the pool is not in use. The question at issue is how much the flow rate can be reduced during hours when the pool is not actually being used without compromising the water quality needed for health reasons. Various aspects of water quality will be monitored, including the following:

- Turbidity or clarity of the water;
- pH level (which needs to be maintained between 7.2 and 8.0);
- Free chlorine residuals;
- Bacteriological quality of the water; and
- Chemical quality of the water.

Proposed Outcomes:

- Optimized energy efficient strategy for operating swimming pool filter pumps.
- Feasibility analysis based on performance of modified pump operation at test sites.

Anticipated Benefits:

- Estimated energy savings of 20,000 kWh per year per pool based on a 25% deduction in flow rate for 8 hours per day.
- Potential to save 840 MWh per year in CA from approximately 40,000 candidate pools.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report submitted and is under review
- Feasibility Analysis Initiated.

Counter Rotating Wind Turbine System**EISG Grant Number:** 00-09**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Kari Appa (949) 458-7314**Organization:** Appa Technology Initiatives**Grant Amount:** \$74,915

Project Description: The purpose of this project is to research the feasibility of developing a more efficient wind turbine by employing a design that incorporates dual, counter-rotating rotor blades. To extract more energy from wind stream, Appa Technology Initiatives (ATI) proposes a counter rotating wind turbine system that enhances the efficiency factor to 40 to 50%. Consequently this will reduce both the energy cost (\$/kWh) and capital cost (\$/kW) by half. To prove this higher energy conversion concept, ATI built a 200-watt counter rotating turbine model. Field tests with load and no load conditions showed satisfactory operational condition of the rotors. Additional tests will be conducted in Tehachapi Pass, where steady wind speed conditions exist. A US patent on the counter rotating turbine system is being awarded to Appa.

Proposed Outcomes:

- Prototype wind turbine with counter rotating rotors
- Improved wind turbine alternator design
- Feasibility analysis based on performance of prototype

Anticipated Benefits:

- Increase wind turbine efficiency by 20-30%
- Achieve power generation cost of 3.5 cents/kWh
- Reduce capital cost of installation due to reduced torque load on support structure
- Retrofit existing utility scale wind turbines with downwind counter rotating turbines for enhancement of power generation.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Draft Feasibility Analysis is completed and is under review

Increasing Efficiency of Geothermal Energy Generation with High Resolution Seismic Imaging**EISG Grant Number:** 00-10**PIER Area:** Renewable Energy Technology**Principal Investigator:** Dimitri Bevc (650) 969-3886**Organization:** 3DGeo Development Inc.**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of improving seismic image resolution of geothermal reservoirs by applying innovative seismic data processing techniques. The approach will be validated against a data set from an existing geothermal field. The efficiency and economy of geothermal energy generation can be greatly increased by obtaining critical reservoir information from active-source reflection seismology. The objective of this project is to improve resolution and imaging of geothermal reservoirs by applying innovative seismic data processing techniques that will directly address the key issues which traditionally plague seismic data collected in geothermal areas; namely:

- Propagation through a highly variable near surface; and
- Imaging steeply dipping complex reservoir structures.

A data processing methodology that facilitates exploration in complex areas, improves geothermal reservoir characterization, and decreases the much higher costs of exploratory drilling and failed water re-injection projects will be developed and demonstrated.

Proposed Outcomes:

- Improved methodology for processing seismic data
- Feasibility analysis based on performance of proposed processing methodology

Anticipated Benefits:

- Reduce the number of wells drilled per geothermal field by 2-5 at a savings of \$1.5-\$4.0 million per well.
- Improve the imaging of geothermal fields with complex near-surface geology in which current imaging technologies do not perform well.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Draft Feasibility Analysis is completed and is under review

Distributed Generation Drivetrain for Windpower Application

EISG Grant Number: 00-11

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Geoff Deane (805) 899-9199

Organization: Dehlsen Associates, LLC

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of an innovative drivetrain design for large-scale wind turbines. As wind turbines have grown, rates of revolution, limited by tip speeds on larger rotor diameters, have decreased while power has increased, increasing the torque seen by the turbines' speed-increasing gearboxes. Because of this detrimental scaling effect, for turbines growing into the megawatt range, gearboxes comprise increasing percentages of the total capital and lifetime costs, limiting the potential for reduction of energy cost. In addition, as turbine size has grown, increasing failures of the larger gearboxes have resulted in the most substantial financial loss to the industry in recent years, posing a serious concern the industry as a whole. Dehlsen Associates has developed and engineered a new gearbox concept, a novel approach to this high-torque, low rotational speed stumbling block.

This proposal outlines a project to demonstrate a 200 kW prototype Distributed Generation Drivetrain (DGD) and to develop the associated controller. The prototype is designed to eventually be installed on a wind turbine, but for the scope of this work, will be tested on a dynamometer. Detailed real-time data will be acquired during the tests to quantify dynamic behavior, efficiency, load balance, and the success of the control strategy. Results of this study will lend insight to the development of a commercial-scale DGD system.

Proposed Outcomes:

- Prototype drivetrain for 200 kW wind turbine
- Prototype controller
- Feasibility analysis based on performance of prototype controller and drivetrain

Anticipated Benefits:

- Reduce the capital cost of installation of large wind turbines

by 7%

- Reduce lifecycle maintenance costs by 30%
- Reduce the cost of power generation from 3.88 cents/ kWh to 3.46 cents / kWh

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Draft Feasibility Analysis is completed and is under review

Energy-Efficient Air-Handling Controls

EISG Grant Number: 00-12

PIER Area: Building End Use

Principal Investigator: Clifford Federspiel (510) 418-3392

Organization: Federspiel Controls

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of a more energy efficient method of controlling air-handling equipment in buildings to minimize the fan power and cooling power required to achieve the functional requirements of ventilation, pressurization and temperature control. The concept is to use extra control degrees of freedom to minimize power consumption while achieving the desired ventilation, temperature, and building pressure conditions. The extra control degrees of freedom arise because there are more control elements (dampers, fan speed controls, heating and cooling coils) than control requirements (ventilation, duct or space temperature, building pressure). A rule-based controller will be designed by deriving rules from the observation of optimal performance.

Existing methods of controlling air-handling systems consume considerably more energy than is necessary to meet the functional requirements of ventilation, pressurization, and temperature control. It is estimated that a nearly optimal control strategy could reduce fan energy consumption by 30% relative to the best current practice and by 60% relative to the typical current practice. In addition to fan power reduction, a nearly optimal strategy could reduce heating and cooling energy consumption by avoiding over-ventilation during hot or cold weather.

Proposed Outcomes:

- Optimized control logic for achieving energy efficient operation of air-handling equipment
- Feasibility analysis based on a comparison of existing and proposed control strategies using modeling and simulation

Anticipated Benefits:

- Reduce fan energy consumption by 20-40%
- Reduce heating and cooling power by 10%
- Potential energy savings of 0.8 quad in the U.S. and 1 quad in California

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Draft Feasibility Analysis is completed and is under review

Omni-Directional Insect Eye Concentrator Using A Hyper-Spectral Photovoltaic Cavity Converter (PVCC)**EISG Grant Number:** 00-13**PIER Area:** Renewable Energy Technologies**Principal Investigator:** C. Wood Hays (760) 744-2575**Organization:** United Innovations, Inc.**Grant Amount:** \$74,992

Project Description: The purpose of this project is to research the feasibility of a high efficiency PV system that utilizes an omni-directional insect eye concentrator (OMNICON) to direct light into a cavity that is lined with single junction solar cells that are coated such that they absorb a specific portion of the light spectrum and reflect the remainder of the spectrum to the other cells in the cavity. OMNIECON combines two new technologies, the omni-directional insect eye to eliminate tracking, and a light-confining cavity for high efficiency. In the cavity, the solar spectrum is split into several frequency bands, and a set of single junction solar cells with complementary band gaps efficiently converts matching photons into electricity. Splitting is caused by selective transmission and reflection of photons with Rugate filters on the cells. OMNIECON can reach collective efficiencies of 45% to 50%.

Proposed Outcomes:

- Optimized system design that incorporates the concentrator, Rugate filters and single junction PV cells
- Feasibility analysis based on modeling and system design

Anticipated Benefits:

- Increase PV efficiency in converting solar energy into electricity from the current level of 8 – 16% to 38%.
- Reduce the installed cost of PV from \$5 - \$6/Watt to \$1.50 - \$3.00/Watt

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Draft Feasibility Analysis is completed and is under review

Highly Conductive, Water Insoluble & Thermally Stable Proton Exchange Membrane (PEM) from Functionalized Polyoxometalates (POMs)**EISG Grant Number:** 00-15**PIER Area:** Environmentally Preferred Advanced Generation**Principal Investigator:** Yuhong Huang (818) 727-9786**Organization:** Chemat Technology, Inc.**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of developing a polymer membrane for a proton exchange membrane (PEM) fuel cell that is highly proton conductive, water insoluble and stable across a wide temperature range. The proposed research is to develop highly proton conductive and thermally stable inorganic electrolytes for a proton exchange membrane fuel cell based on functionalized polyoxometalates (POM) membrane. Polyoxometalate has been proven to have high temperature proton conductivity (0.17 S/cm) and much lower cost than Nafion.

Operation at low and high temperature is desirable, because it allows a variety of operating conditions to be used. Low temperature electrolytes, such as 25 to 60 °C, are suitable for portable fuel cells. High temperature electrolyte, 120 to 140 °C, is desirable for high power larger fuel cells. High temperature fuel cell reduces the impact of carbon monoxide poisoning in reformate air fuel cells and allows attainment of high power density.

Success in developing alternative, thermally-stable conducting materials could have a tremendous impact on fuel cell technology. By eliminating the hydrous component, it is anticipated that water re-circulation hardware will not be necessary and thermal management issues will be relieved, thus greatly simplifying the overall fuel cell system.

Proposed Outcomes:

- Methodology for producing polymer membranes with the specified characteristics
- Feasibility analysis based on single cell performance testing of the most promising prototype membrane. Fuel Cell

Energy will conduct cell testing. Samples will be sent to JPL NASA for evaluation

Anticipated Benefits:

- Increase PEM fuel cell reliability and lifespan
- Reduce PEM fuel cell manufacturing costs by reducing the cost of the membrane from \$500-\$1000/m² for Nafion to \$2/m² for the proposed membrane

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress.

Development of Optimum Design Configuration and Performance for Vertical Axis Wind Turbine

EISG Grant Number: 00-17

PIER Area: Renewable Energy Technologies

Principal Investigator: Hamid R. Rahai (562) 985-5132

Organization: CSU Long Beach Foundation

Grant Amount: \$69,781

Project Description: The purpose of this project is to research the feasibility of improving the efficiency of vertical axis wind turbines by optimizing the blade design through numerical modeling. Two subscale prototypes will be fabricated and tested, one with an optimized mono airfoil and one with an

optimized two element airfoil. The objective of the project is to improve the performance of vertical axis wind turbines for residential and commercial applications. Recent studies suggest that increasing the efficiency of this type of turbine requires increased contribution from the lift force to generate torque. The present proposal will implement numerical techniques for optimizing highly cambered thin airfoils (which have similar shapes as high lift airfoils) for use in a high-efficiency, vertical-axis wind turbine. Using optimized blades, scaled model turbine will then be built and tested in the wind tunnel.

Proposed Outcomes:

- Two subscale prototype wind turbines with optimized blades
- Methodology for optimizing blade designs
- Feasibility analysis based on performance of prototype turbines

Anticipated Benefits:

- Increase vertical-axis wind turbine efficiency by 20 - 30%
- Cost-effective, vertical-axis wind turbines that could be used for distributed generation applications

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress.

SOLICITATION 00-01

Closed-Cycle Valved Cell Heat Engine

EISG Grant Number: 00-01

PIER Area: Renewable Energy Technology

Principal Investigator: Joseph Bland (916) 429-6252

Organization: Individual

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of fabricating a low cost heat engine that is capable of operating efficiently on low-temperature external heat sources. This project will construct, test and analyze a proof-of-principle prototype of a closed-cycle Valved Cell Engine (VCE). The objectives of the project are to determine if it is technically and economically feasible to fabricate the proposed engine design and to establish that the proposed design is capable of operating effectively from external heat sources in the range of 500-800° F. The VCE is targeted at low temperature heat sources because of its unique ability to deliver very high work output per pound of working fluid (about 50% greater than that of a comparable Stirling engine). The VCE can operate effectively and efficiently at these very low source temperatures. This makes it an ideal heat engine for solar, geothermal and waste heat applications. The VCE's power density also means it can tap efficiently into very small heat sources.

Proposed Outcomes:

- Prototype closed-cycle valved cell engine.
- Feasibility analysis based on prototype performance.

Anticipated Benefits:

- Low cost heat engine design capable of generating 2-3 kW from concentrated solar or other low temperature sources.
- 0% higher work output per pound of working fluid compared to a sterling engine.
- Low capital cost with 3-5 year pay back period.
- Zero emissions when operated from solar energy.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress

Single Crystal Silicon Sheet Growth

EISG Grant Number: 00-02

PIER Area: Renewable Energy Technology

Principal Investigator: Carl Bleil (248) 370-3406

Organization: Energy Materials Research

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of producing single crystal sheets of semiconductor quality silicon directly from a polycrystalline source at a minimum production rate of 35 cm/min up to maximum of 350 cm/min using an advanced Horizontal Ribbon Growth (HRG) method. The patented approach presented here and validated in the laboratory addresses the critical control features of a modified HRG process necessary to realize the continuous growth of single crystal silicon sheets. A unique concept invoking capacitive coupling of RF power to the silicon sheet seed is employed. When properly applied in a uniform thermal environment, it allows disturbances at the nucleating tip and at the exit solid-liquid phase boundary to be eliminated. The problems of maintaining a uniform thermal environment, controlling temperature gradients, and preventing polycrystalline nucleation are resolved. The process permits the stable growth of the silicon sheet to be controlled electrically, making the HRG method a practical process.

Proposed Outcomes:

- Prototype Horizontal Ribbon Growth processor.
- Production methodology.
- Technical and economic feasibility analysis of proposed methodology.

Anticipated Benefits:

- 50% reduction in the energy consumed to produce quality silicon sheet.
- 40% reduction in the material losses associated with producing single crystal sheets.
- Potential 50% capital cost reduction of electronic grade silicon sheets.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress

Corrosion Resistant Coating for Carbonate Fuel Cell Components

EISG Grant Number: 00-05

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Yuhong Huang (818) 727-9786

Organization: Chemat Technology, Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of increasing the life of molten carbonate fuel cells by using a sol-gel coating of LiCOO_2 on the NiO cathode and cathode current collector to reduce corrosion. The primary objective of this proposed research is to solve one of the most serious problems in molten carbonate fuel cells: corrosion of cathode current collector and lithiated NiO cathode, which has been a major lifetime-limiting factor. In this proposed project, a sol-gel coating process will be developed to improve the performance of cathodes and cathode current collector. By carefully selecting the coating materials, the corrosion resistance can be enhanced dramatically. Consequently, the lifetime and power generation efficiency of this fuel cell can be improved simultaneously.

Proposed Outcomes:

- Material samples will be fabricated with sol-gel coating
- Methodology for applying sol-gel coating
- Feasibility analysis based on performance of material samples

Anticipated Benefits:

- Increase fuel cell life by 100%
- Increases capital cost of cathode and current collector by less than 2%

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress.

Biomass Boundary Layer Turbine Power System

EISG Grant Number: 00-06

PIER Area: Renewable Energy Technologies

Principal Investigator: Darren Schmidt (701) 772-5281

Organization: EnergySchmidt

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of driving a boundary layer turbine with

a low-cost biomass combustor for the purpose of generating electricity. The boundary layer turbine is the key component for creating an economical small biomass power system. The expected capital cost of the first systems would be \$600/kW. The technology proposed here is addressing the problem of integrating small biomass power systems into the distributed generation market. The solution in this proposal could potentially lead towards the development of a small power system that would economically compete directly with diesel engines in the distributed power generation market. The proposed technology would consist of coupling a boundary layer turbine with a biomass combustion system to produce electricity and heat. The boundary layer turbine is attractive because it would allow for much higher concentrations of contaminants in the gas stream relative to current commercial turbines and reciprocating engines.

Proposed Outcomes:

- Prototype system
- Biomass combustor design compatible with boundary layer turbine
- Feasibility analysis based on prototype performance

Anticipated Benefits:

- Divert combustible biomass from landfills
- Reduce emissions from open air burning of biomass
- Reduce NO_x and CO_2 emissions to the extent that it offsets power generation from fossil fuels
- Fixed and portable biomass power generation systems that are durable and require less maintenance
- System capital cost of \$600/kW with a 6.7 year payback from a 1-MW system

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility Analysis Report - Analysis in progress.

Improved Performance of Energy Recovery Ventilators Using Advanced Porous Heat Transfer Media

EISG Grant Number: 00-07

PIER Area: Building End Use

Principal Investigator: Mark Tillack (858) 534-7897

Co-Principal Investigator: Rene Raffray (858) 534-9720

Organization: UC San Diego

Grant Amount: \$74,762

Project Description: The purpose of this project is to research the feasibility of using advanced porous media to increase the heat transfer efficiency of heat recovery ventilators to 90% (current technology is 50-80% efficient). The current trend toward sealing houses to reduce air and moisture infiltration makes them more energy efficient and reduces home energy costs. Depending on the local climate, appliance use and sealing method, tighter houses can be 15% to 30% more energy efficient. However, as homes and commercial buildings become more leak tight, adequate ventilation becomes increasingly important in order to avoid air quality problems.

If a house is constructed tighter than 0.35 air changes per hour, any pollutants generated in the home can accumulate and reduce the indoor air quality to unhealthy levels. If fresh outside air is brought in through an open window to alleviate this problem, this air may be excessively hot, cold or humidity-laden and require conditioning at added expense. Energy recovery ventilators (ERVs) use air-to-air heat exchangers to retain building heat or cooling. The heart of the system is the heat exchanger, which in some cases is used also to aid in filtration and/or humidity control. Substantial improvements in heat transfer efficiency are possible using modern low-cost gas-phase heat exchanger technology. Increasing the heat transfer effectiveness to 90% would provide a factor of 2-5 decrease in energy loss.

Proposed Outcomes:

- Fabrication of porous medium samples
- Optimized heat recovery ventilator design
- Feasibility analysis based on performance of test samples

Anticipated Benefits:

- Provide a cost effective and energy efficient means of maintaining indoor air quality in structures that are built airtight
- Encourage the construction of airtight houses that are 15%-30% more energy efficient

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report Draft completed - in Technical Review
- Feasibility analysis Report - Analysis in progress.

SOLICITATION 99-04

Direct Operation of Solid Oxide Fuel Cells (SOFCs) on Natural Gas

EISG Grant Number: 99-30

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Scott A. Barnett (847) 491-2447

Organization: Northwestern University

Grant Amount: \$74,958

Project Description: The purpose of this project is to research the feasibility of operating solid oxide fuel cells directly on natural gas. The key problems are to verify that the hydrocarbons can be electrochemically oxidized while avoiding carbon deposition at the fuel cell anode. For this, it will be necessary to explore alternate SOFC anode compositions. Anode performance will be characterized by chemical detection of carbon on the anodes, impedance spectroscopy, and fuel cell current-voltage measurements. The key problems are to verify that these higher hydrocarbons can be electrochemically oxidized and avoiding carbon deposition at the fuel cell anode.

For this, it will be necessary to explore alternate SOFC anode compositions. Anode performance will be characterized by chemical detection of carbon on the anodes, impedance spectroscopy, and fuel-cell current- voltage measurements. This project will show the feasibility of natural-gas-fueled SOFCs and identify new anode materials.

Proposed Outcomes:

- New anode materials capable of oxidizing hydrocarbons without carbon deposition and capable of preventing the sulfur in natural gas from poisoning the fuel cell.
- Prototype single-cell SOFCs fabricated with the new anode materials.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce the cost and complexity of fuel cells by eliminating the need for a natural gas fuel reformer.

- Accelerate the commercialization of low cost residential fuel cells in California where low cost natural gas is already widely distributed.
- Reduction in CO₂ by facilitating the use of natural gas in fuel cells that operate at higher efficiencies than central power plants.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed
- Feasibility Analysis Report completed

Non-vacuum Thin-film Photovoltaics (PV) Processes**EISG Grant Number:** 99-31**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Chris Eberspacher (805) 987-7258**Organization:** Unisun**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of a low cost alternative to the capital intensive vacuum techniques used to deposit thin coatings of photoactive materials in the manufacture of thin film PV. The proposed process involves depositing thin layers of particulate precursor materials and sintering the layers into high-quality PV films. One of the most promising strategies for lowering the cost of photovoltaics is the use of thin-film technologies in which thin coatings of photoactive materials are deposited on inexpensive substrates like window glass. However, the vacuum techniques typically used to deposit PV thin films are complex and capital intensive. This project will explore a simple, low-cost alternative based on non-vacuum processes.

The basic concept is to prepare fine powders of precursor materials, deposit thin layers of particulate precursor materials using simple non-vacuum techniques, and convert the layers into high-quality PV films by reactive sintering techniques. Particles simplify composition control for multi-component materials such as CuIn_{1-x}Ga_xSe₂ (CIGS). Layers of particles can be deposited on large-area substrates with simple non-vacuum techniques such as printing, spraying or spin-coating. Reactive sintering techniques facilitate film densification at low temperatures. Non-vacuum, particles-based processes minimize capital equipment costs, reduce manufacturing costs and increase return on investment.

Proposed Outcomes:

- Material deposition equipment that meets performance specifications.
- Application technique that yields +/- 10% thickness uniformity, > 40% packing density, and > 85% materials use efficiency
- Prototypes of thin film PV capable of 12% efficiency as single.5 cm² cells and 8% efficiency as 5 cm² integrated modules.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce projected manufacturing cost by 50% relative to vacuum-based thin-film PV technologies while maintaining efficiencies of 8% in modules.
- Accelerate the commercialization and market penetration of thin-film CIGS PV products.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

The Use of Solid Oxide Membranes in Power Generation Applications**EISG Grant Number:** 99-32**PIER Area:** Environmentally Preferred Advance Generation**Principal Investigators:** Fokion Egolfopoulos (213) 740-0480 and Theodore Tsotsis (213) 740-2069**Organization:** University of Southern California**Grant Amount:** \$75,000

Project Description: The purpose of this project is to evaluate the technical feasibility of using the waste heat in the exhaust stacks of power generating equipment to decompose CO₂ through the use of solid oxide membranes and to then mix the decomposed elements (CO and O₂) into the fuel stream to augment combustion thereby increasing thermal efficiency. The key objective of the proposed work is to evaluate technical feasibility, environmental implications, and long-term economic viability of a novel technology that improves electric power generation efficiency while simultaneously providing an avenue for CO₂ sequestration.

The technology combines direct thermal CO₂ decomposition with an advanced power generation concept involving waste heat utilization and integration by chemical recuperation, otherwise known as the CRGT cycle. More specifically, a high-

temperature, asymmetric, solid-oxide membrane reactor technology will be developed that will allow for the direct thermal CO₂ decomposition into CO and O₂, while simultaneously utilizing waste heat in the context of power generation. The feasibility study will first focus on the choice and testing of the appropriate membrane material. Subsequently, the combustion characteristics of the resulting fuel blends of CH₄/CO/CO₂/O₂/N₂, will be systematically quantified since their combustion characteristics have not been studied systematically in the past.

Proposed Outcomes:

- Membrane technology that will be appropriate for the direct thermal decomposition of CO₂.
- Quantification of the combustion characteristics of fuel blends of CH₄/CO/CO₂/O₂/N₂.
- Feasibility assessment based on the prototype membrane and combustion testing.

Anticipated Benefits:

- Reduce the cost of power generation in systems that utilize combustion by using the waste heat to improve thermal efficiency or by selling the decomposed elements (CO and O₂) to partially offset the cost of generation.
- Reduce CO₂ emissions and would enable CO₂ sequestration if desired.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed Feasibility Analysis Report completed

Two-Phase Flow Turbine for Co-generation, Geothermal, Solar and Other Applications

EISG Grant Number: 99-33

PIER Area: Renewable Energy Technologies

Principal Investigator: Gracio Fabis (818) 952-0217

Organization: FAS Engineering, Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of a new design for a two-phase flow turbine capable of operating at higher thermal efficiencies in geothermal power generation applications. Use of two-phase turbines (hot water plus steam) in small size cogeneration has substantial advantage over gas turbine cogeneration. The reason is that in the Brayton cycle case the compressor uses up over 70% of mechanical power delivered by the gas turbine. When steam is used, the compression power is only a few percentage

points of the two-phase turbine power output. Various market applications are already mentioned. Early implementation could be to retrofit topping part of the existing, both, flash and binary type geothermal power plants. Small size early applications for waste heat utilization and cogeneration involving water and spaced heating are attractive as well. Efficiencies and economics obtainable using this device and its thermal cycles (topping flash retrofits, cogeneration, trilateral, heat pumps and others) are favorable.

Proposed Outcomes:

- 30 kW subscale prototype turbine.
- Measure efficiency values.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Increases turbine thermal efficiency by 20% - 40% in binary and flash type geothermal applications.
- Potential to increase efficiency in solar and thermal waste heat applications.
- Design is scalable to both small and large turbine applications.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed
- Feasibility Analysis Report completed

Composite Architectures for Sub-6000C Solid Oxide Fuel Cells

EISG Grant Number: 99-35

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Lutgard De Jonghe (510) 486-4881

Organization: UC Berkeley

Grant Amount: \$70,811

Project Description: The purpose of this project is to research the feasibility of producing a composite solid oxide fuel cell (SOFC) membrane assembly that optimally combines reforming and catalytic functions with high cathode and anode electronic conductivity. The methods used involve colloidal processing techniques, offering potentially low fabrication costs. The ceramic SOFC membranes have a novel composite architecture that optimally combines the reforming and catalytic functions with high electronic conductivity, through the choice of materials and microstructure. The methods by which the composite membranes are produced involve colloidal

processing and common ceramic processing techniques, thereby avoiding costly production steps, and therefore significantly enhance the feasibility of the concept.

Decreasing the temperature of operation of an SOFC, down from the current 1000°C operation, can significantly alleviate materials compatibility and durability problems in the SOFC stack, reducing the cost of this technology while maintaining its advantages. Increasing the materials and system reliability and lowering cost of SOFCs are essential factors in enabling broad commercial introduction of the energy efficient SOFC technology, both at the residential and small to intermediate industrial scale.

Proposed Outcomes:

- Prototype fuel cell membrane with an overall membrane resistance of less than 1 ohm/cm² that can operate efficiently at or near 600°C.
- Fabrication process for low-cost fuel cell membranes.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce the manufacturing cost of solid oxide fuel cells as a result of reducing the operating temperature that reduces the need for expensive materials.
- Increase the reliability of solid oxide fuel cells by reducing material compatibility problems that are caused by high operating temperatures.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Feasibility Analysis is Initiated

Energy Production from Bulk Wastewater Using Optimized Supersynthetic Bacteria

EISG Grant Number: 99-36

PIER Area: Renewable Energy Technologies

Principal Investigator: Eric McFarland (805) 893-4343

Organization: UC Santa Barbara

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of producing wastewater microorganisms capable of efficient biosynthesis of hydrogen gas. The most promising microorganisms will be cultured and tested in a prototype sub-scale anaerobic digester. Anaerobic digesters have no free oxygen. Anaerobes get oxygen by the

decomposition of compounds containing it. The technical objective of this project is to develop a means for the efficient, economic, biosynthesis of hydrogen gas (H₂) in wastewater anaerobic digesters for use as an environmentally clean fuel. Though scheduled first for automobile use, future electricity generation systems will increasingly use hydrogen if a cost-effective source of hydrogen gas becomes available. While hydrogen can be produced by reformation, decomposition, or electrolysis, these methods are relatively energy intensive or utilize non-renewable resources. An attractive alternative for H₂ production has been biosynthesis; however, to date the practical realization of bulk hydrogen synthesis from living organisms has not been achieved.

Proposed Outcomes:

- Combinatorial methodology for screening microorganisms capable of optimal H₂ production.
- Prototype bench top digester/bioreactor.
- Feasibility analysis based on performance testing of selected microorganisms in prototype bioreactor.

Anticipated Benefits:

- Demonstrate the effectiveness of combinatorial methodology in the screening of numerous genetically diverse mutant microorganisms for optimal H₂ production.
- Increase H₂ production from wastewater anaerobic digesters to a level that makes power generation commercially viable.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Feasibility Analysis is Initiated

Anaerobic Pump

EISG Grant Number: 99-38

PIER Area: Renewable Energy Technologies

Principal Investigator: Keith Schimel (315) 425-7741

Organization: Technology Matrix Corp.

Grant Amount: \$71,000

Project Description: The purpose of this project is to research the feasibility of a new two-stage anaerobic digester design capable of converting wet biomass to methane. The Anaerobic Pump (AP) is a two stage, hybrid anaerobic process for converting wet biomass to biogas (methane, carbon dioxide and ammonia gases). The unique reactor design drives hydrolysis due to including a combination of three technical advancements:

- Gas transfer via applied low pressure,
- Automatic in-reactor substrate and bacterial thickening, and
- Plasticization via applied high pressure.

Conventional Anaerobic digestion achieves limited volatile solids reduction (20-40%) because it is based on gas-liquid equilibrium. Instead, the Anaerobic Pump utilizes the gases produced by anaerobes to drive hydrolysis via innovative pressure swing design. The objective of this project is to test the Anaerobic Pump's ability to completely convert a waste sludge mixture, including the nondigestible fraction of the sludge mixture, through three steady states.

Proposed Outcomes:

- Subscale prototype system.
- Quantitative test data on prototype operation under three steady-state conditions.
- Feasibility analysis based on performance of prototype system.

Anticipated Benefits:

- Provide an efficient method of producing methane from renewable industrial and agricultural wastewater streams which could be used to produce 200-400 MW valued at \$5-\$10 million per year.
- Increase conversion of volatile solids from 40% to approximately 90% through use of the two stage anaerobic digester, which significantly reduces disposal costs and volume of the remaining material.
- Mitigate California groundwater contamination associated with land disposal methods of animal and municipal wastes.
- Reduce greenhouse gas emissions of methane into environment.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

High-Efficiency Single Phase Air Conditioner

EISG Grant Number: 99-39

PIER Area: Building End-Use Efficiency

Principal Investigator: Otto Smith (510) 525-9126

Organization: Individual

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of a motor controller that enables high-efficiency, three-phase air conditioners to be operated from a single-phase power source that is typical in residential and rural locations. This project will provide a control that enables high-efficiency three-phase air conditioners to be supplied directly from single-phase residential outlets and rural electrical connections. The "enabler" has starting capacitors and motor-run capacitors in addition to the usual line contactor and starting contactor.

Proposed Outcomes:

- Prototype motor controller.
- Quantitative test data of three phase and single phase AC units operating on single phase power under controlled conditions.
- Feasibility analysis based on prototype performance.

Anticipated Benefits:

- Reduce air conditioning electrical consumption by 10%.
- Reduce voltage drop and current spike during start up.
- Improve power factor

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed
- Feasibility Analysis Report completed

SOLICITATION 99-03

Novel Composite Membranes for Fuel Cells

EISG Grant Number: 99-19

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Sossina Haile (626) 395-2958

Organization: California Institute of Technology

Grant Amount: \$74,942

Project Description: The purpose of this project is to research the feasibility of fabricating an anhydrous solid acid electrolyte membrane for fuel cell applications. Among the various electrolytes known for fuel cell applications, solid polymer electrolytes are particularly attractive because they permit fuel cell operation at temperatures close to ambient. Despite progress towards the commercialization of such fuel cells, market entry has not yet been realized. Key engineering challenges remain because:

- The polymer must be maintained in a hydrated state during fuel cell operation;
- The polymer may not be exposed to temperatures exceeding ~ 100C; and
- The polymer is permeable to fluids such as methanol.

The need for hydration implies costly water recirculation hardware; the need for temperature control implies that reaction kinetics (and thereby efficiencies) cannot be improved by operation at slightly elevated temperatures, and the permeability to methanol precludes the development of direct methanol fuel cells (DMFCs) based on polymer electrolytes. Success in developing alternate, anhydrous proton conducting materials could have a tremendous impact on fuel cell technology. By eliminating the hydrous component, it is anticipated that water recirculation hardware will not be necessary and thermal management issues will be relieved (greatly simplifying the overall fuel cell system). Also, slightly elevated temperature operation will be possible (enhancing catalyst performance, increasing efficiency, and further simplifying the overall fuel cell system by improving CO tolerance). Methanol transport across the electrolyte will be negligible (enabling the development of high efficiency DMFCs.). Interest in these membranes has already been expressed by a number of industrial entities including General Motors, EPRI, Arthur D. Little, Allied Signal and Hughes Research Laboratories.

Proposed Outcomes:

- A subscale prototype fuel cell will be fabricated and tested
- Prototype polymer/solid acid composite membrane.
- Prototype subscale membrane electrode assembly (single cells 5 cm²).

- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Extend the capability of polymer electrolyte membrane (PEM) fuel cells to operate as direct methanol fuel cells, which eliminates the need for costly methanol reformers.
- Eliminate the need for costly internal water hydration system that is needed for the traditional polymer membranes thus greatly simplifying the overall fuel cell system, which reduces cost.
- Enable PEM fuel cells to operate at higher more efficient temperatures.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted
- Revised Draft Final Report has been submitted.
- EISG Program Administrator is in the process of finalizing the Feasibility Analysis Report for publication.

Development of a Unique Gas Generator for a Non-Polluting Power Plant

EISG Grant Number: 99-20

PIER Area: Energy Related Environmental Research

Principal Investigator: Roger Anderson (916) 635-1606

Organization: Clean Energy Systems (CES)

Grant Amount: \$74,871

Project Description:

The purpose of this project is to research the feasibility of fabricating a combustor for a gas turbine that eliminates the production of NO_x, SO_x, CO, VOCs and particulates. This project will conduct applied research to develop and demonstrate a new gas generator concept. The gas generator combusts hydrocarbon (methane) fuel with pure oxygen to produce a turbine drive gas. Although supporting analyses have been completed, unique aspects of this device need to be physically demonstrated. Testing a sub-scale, single element unit will demonstrate:

- That the premix injector element design produces uniform and complete mixing of the fluids before injection;
- That reliable ignition and stable combustion of the

injected fluids occurs at several temperatures and pressures; and

- That the resultant gas generated has a defined composition and energy.

The CES concept enables the construction of extremely compact (high power density), high efficiency gas generators that can produce a high energy, environmentally clean, two-species gas (H₂O, 90%v and CO₂, 100%v) for driving advanced turbo-generators. The device can operate on any clean, light hydrocarbon fuel and oxygen. This device is an enabling subsystem in the design of non-polluting, economical electrical power generating plants. CES is corresponding with six international power system manufacturing companies and they are evaluating the potential of their turbine technologies to take advantage of this gas generator's capabilities. The Lawrence Livermore National Laboratory and several industrial firms have agreed to team on a CES proposal to DOE to build a facility to demonstrate both non-polluting power generation and economical sequestration of CO₂.

Proposed Outcomes:

- A subscale combustor will be fabricated and tested.
- Results of performance tests to include operation of the premix injector, ignition system and combustion stability.
- Analysis of emissions in drive gas produced during prototype testing.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Provide gas turbine electrical generation capability with zero pollution emissions.
- System would allow inexpensive capture of CO₂ since the exhaust would be comprised of 90% water and 10% CO₂ if full combustion of the O₂ and methane is achieved.

Project Status

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

Integral Catalytic Combustion/Fuel Reforming for Gas Turbine Cycles

EISG Grant Number: 99-21

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Gregory Jackson (310) 405-2368

Organization: University of Maryland

Grant Amount: \$74,992

Project Description: The purpose of this project is to research the feasibility of a novel gas turbine combustor that incorporates catalytic combustion with steam reforming of H₂ that results in a stable ultra-low NO_x combustion system for high temperature gas turbines. To extend the operability/flexibility of catalytic combustors, the University of Maryland (UMCP) in collaboration with UC-Berkeley (UCB) is proposing to investigate a novel reactor concept incorporating catalytic combustion with steam reforming to provide a stable ultra-low NO_x combustion system for high firing temperature gas turbine cycles.

The reactor, which will consist of alternating catalytic combustion and reforming flow paths in a stacked configuration, will provide a unique means of avoiding overheating of the catalytic combustor. Furthermore, the reactor will also produce a secondary stream of H₂ that may be used for flame stabilization in the combustor or may be sent to a fuel cell in a future combined power plant. Also, the implementation of new high-temperature hexaluminate catalysts and supports will enhance the long-term durability of the reactor and the ability of the reactor to work in higher firing temperature gas turbines. Thus, the innovative reactor concept will provide improved operability and performance of catalytic combustors through the following:

- 1) Reduced susceptibility to overheating to allow lower quality premixing and potentially higher equivalence ratios in catalytic combustors;
- 2) Potential for improved downstream flame stabilization via H₂ addition; and
- 3) Increased flexibility with fuel content while maintaining ultra-low NO_x emissions.

Proposed Outcomes:

- A subscale reactor will be fabricated and tested.
- Subscale prototype reactor.
- Analysis of reactor effectiveness under high-pressure/high temperature conditions.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce gas turbine NO_x emissions to below 5 ppm.
- Improve the thermal efficiency of gas turbines by allowing the catalytic combustor to operate at higher temperatures.
- Efficient production of H₂ that could be used for downstream flame stabilization or sent to a fuel cell for additional electrical generation.

Project Status:

- 100% complete
- Completed behind Schedule
- Completed within budget
- Draft Final Report completed
- Feasibility Analysis in process
- Reduced Cost Power Electronic Converter for Generator Applications

Plug-In Photovoltaic Receiver for Concentrator Applications**EISG Grant Number:** 99-22**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Pierre Verlinden (408) 991-0910**Organization:** SunPower Corporation**Grant Amount:** \$74,977

Project Description: The purpose of this project is to research the feasibility of fabricating a standardized plug-in photovoltaic (PV) receiver for Fresnel-lens concentrator systems. High-concentration photovoltaic systems hold the potential to dramatically reduce the cost of PV electricity. By concentrating sunlight with inexpensive plastic lenses, the required area of costly solar cells can be dramatically reduced. In addition, high-concentration PV systems are more efficient - compared to conventional flat-plate silicon photovoltaic panels, they can generate about 40% to 60% more energy per unit area on an annual basis.

SunPower Corporation will develop a standardized, highly reliable, plug-in photovoltaic receiver for high-concentration Fresnel-lens systems. The plug-in PV receiver would be factory assembled and would include the following components in a single package: a PV cell, a substrate, a secondary optical element, a bypass diode, a heat spreader and heat sink, and exterior electrical and mechanical connections. The yearly energy output per unit area of this PV concentrator system is expected to be much greater than a conventional flat-plate silicon module, significantly reducing balance of system (BOS) costs. For moderate volume production, the installed cost of this system will be about \$3000/kW, or about half of the cost of today's flat-plate PV systems.

Proposed Outcomes:

- Up to four prototypes receiver units will be built and tested.
- Prototype plug-in PV receiver module.
- Specifications for plug-in PV receiver module.
- Process steps for device fabrication.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduces the installed cost of fully integrated PV concentrator systems to about \$3,000/kW which is less than half the cost of current flat-plate PV systems.
- Increases the performance and reliability of concentrator systems by integrating into a single module, under factory controlled conditions, the PV cell, substrate, secondary optical element, bypass diode, heat spreader, heat sink and electrical and mechanical connections.

Project Status

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

Reduced Cost Power Electronic converter for Generator Applications**EISG Grant Number:** 99-23**PIER Area:** Industrial/Agriculture/Water End-Use Efficiency**Principal Investigator:** Herbert Hess, (208) 885 4341**Organization:** University of Idaho**Grant Amount:** \$74,977

Project Description: The purpose of this project is to research the feasibility of developing a more efficient and lower cost power electronic converter for use in variable speed electrical generation applications such as wind and water turbines or gas microturbines. The following three innovative, concurrent changes from the conventional method of generating with any variable-speed, turbine-generator system, like a wind-turbine generator, are proposed:

- 1) Reduce the number of power switching devices by half;
- 2) Develop a new modulation algorithm that takes advantage of common, but usually neglected filtering properties of the induction machine; and
- 3) Configure a simple filter topology to capture the energy produced by the system.

The modified system has the following advantages over the conventional means of variable-speed, wind turbine induction motor systems:

- Approximately half the capital cost of the power electronic converter,
- Retains the advantages of variable speed operation without modification to the generator itself,
- Energy savings come from reduced line losses and improved ability to operate the load nearer its optimum power output and efficiency,

- improved system performance, particularly in the case of generating behind long radial lines, with a controllable source of both real and reactive power having very low harmonic content to enhance clean, stable operation, usable as is for variable speed conversion capability for any turbine generator, such as hydro, gas microturbines, etc.

Proposed Outcomes:

- A prototype converter will be fabricated and tested.
- Prototype power converter rated for 15 horsepower.
- Control algorithm for the dc bus.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Reduce by 50% the capital cost of power electronic converters for variable speed applications.
- Enables turbines to operate at their optimum power output and efficiency.
- Saves energy by reducing line losses.
- Eliminates need to modify the generator for variable speed operation.

Project Status:

- 100% complete
- Completed behind Schedule
- Completed within budget
- Draft Final Report being refined

Attic and Crawl Space Ventilation Air Heat Exchanger**EISG Grant Number:** 99-24**PIER Area:** Building End-Use Efficiency**Principal Investigator:** G. Z. Brown (541) 346-5647**Organization:** University of Oregon**Grant Amount:** \$75,000

Project Description: The purpose of this project is to research the feasibility of developing a low-cost, air-to-air heat exchanger capable of 50% or greater efficiency for use in residential and small commercial buildings. Utilizing a heat exchanger to temper the air before conditioning it will result in reduced building loads leading to down sizing of the HVAC equipment. It will also reduce energy consumption and electrical demand. The primary problem of current heat exchangers is how to reduce their cost so energy savings can pay back the initial cost of the heat exchanger in a short period of time. One solution to this problem is to exploit underused areas in residential and small commercial buildings - the crawl space or attic - to increase heat exchanger surface area and to

use thin film tubes to reduce cost. Existing heat exchangers concentrate on reducing overall size while maintaining efficiency. Competitive heat exchangers include finned-tube, plate, heat pipe, and enthalpy, which are more expensive.

Proposed Outcomes:

- Two or more full-scale prototype air-to-air-heat exchanges.
- Hardware connection designs for conventional HVAC equipment.
- Feasibility assessment based on prototype performance testing.

Anticipated Benefits:

- Potential energy savings of 825 GWh/yr in California assuming only 10% and 1% market penetration in the residential and commercial building sector respectively.
- Reduce the installed cost of air-to-air heat exchangers by up to 90%.
- Improve the indoor air quality in modern airtight residential housing by providing a cost effective device for conditioning outside ventilation air.

Project Status

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

Reducing Cost and Environmental Impact of Geothermal Power Through Modeling of Chemical Processes in the Reservoir**EISG Grant Number:** 99-25**PIER Area:** Renewable Energy Technologies**Principal Investigator:** Subir Sanyal (510) 527-8164**Organization:** GeothermEx, Inc.**Grant Amount:** \$71,390

Project Description: The purpose of this project is to research the feasibility of incorporating the recently developed TOUGHREACT code for chemical interactions into the existing TOUGH2 simulation model used for geothermal operations. Geothermal power in California today cannot compete with power from gas-fired plants because of geothermal's higher operations and maintenance ("O&M") cost. Geothermal energy's high O&M cost is due in part to the chemical problems related to geothermal fluids: deposition of chemical scales, corrosion, non-condensable gases, etc.

The O&M cost of geothermal electricity could be lowered if

these processes could be quantitatively modeled on the computer so that optimized mitigation steps can be taken. Such modeling will also allow enhanced reservoir management and reduction of environmental impact through minimizing gas emissions by injection optimization, and allow estimation of mineral recovery from geothermal brines. Reduction of O&M cost, enhancement of reservoir management and mineral recovery are all identified as elements of "focus" in the CEC's "Geothermal RD&D Needs and Approaches." The reduction in O&M cost and enhanced reservoir management could save on the order of 0.25 cents/kWh for most projects.

GeothermEx, Inc. proposes to work in collaboration with LBNL to apply TOUGH2 and TOUGHREACT software to solve a set of practical chemical problems encountered in several typical geothermal fields in California. These problems, drawn from published industry experience, would include:

1. Recovery of valuable minerals (such as zinc, silver and manganese) from geothermal brines;
2. Scale deposition around wells;
3. Effects of injecting acidic brine originating from various fluid handling processes;
4. Minimizing gas production through optimized water injection; and
5. Modeling of chemically reactive tracer tests to enhance reservoir management.

Proposed Outcomes:

- Produce a comprehensive geothermal model that integrates TOUGHREACT code with the TOUGH2 model.
- Feasibility assessment based on model's ability to perform under real-world conditions.

Anticipated Benefits:

- Reduce the cost of electricity generated by geothermal operations by .25 cents/kWh.
- Optimize mineral extraction strategies for California's high-salinity geothermal reservoirs.

Project Status

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted
- Revised Draft Final Report has been submitted

Catalytic Stabilizer for Industrial Gas Turbines

EISG Grant Number: 99-26

PIER Area: Energy Related Environmental Research

Principal Investigator: Shah Etamad (203) 787-8626

Organization: Precision Combustion, Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of developing an ultra-low NO_x catalytic pilot burner for advanced industrial dry low-NO_x (DLN) gas turbines. This project will test the feasibility of a novel Precision Combustion, Inc. concept for an ultra-low NO_x catalytic stabilizer to replace existing high NO_x pilot burners now used for start-up, turndown and base-load combustion stabilization in advanced and current industrial dry low-NO_x gas turbine machines. The project targets gas turbine power generation problems of pollutant emissions and the capital, efficiency, and operating costs incurred in minimizing generation of those pollutants. The concept is suitable for both new engines and retrofits. Potential benefits include:

- Substantial reduction in NO_x emissions (to the low and middle single digit range);
- Improved combustion stability;
- Low combustion acoustics;
- Improved component life; and
- Avoiding aftertreatment costs and inefficiencies.

Proposed Outcomes:

- Full scale prototype of the low NO_x catalytic pilot burner.
- Feasibility assessment based on prototype performance testing in Taurus 60 combustor test rig.

Anticipated Benefits:

- Reduce NO_x emissions from dry low NO_x gas turbines from 25 ppm to below 9 ppm and reduce CO emissions to less than 5 ppm.
- Provide cost effective alternative to expensive after treatment NO_x reduction technologies.
- Designed for retrofit market and new turbine construction which increases its potential impact on California emissions.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed
- Feasibility Analysis Report completed
- Reports approved for publication

Ventilation Cooling Controller Strategies

EISG Grant Number: 99-28

PIER Area: Building End-Use Efficiency

Principal Investigator: Murray Milne (310) 454-7328

Organization: UCLA

Grant Amount: \$74,895

Project Description: The purpose of this project is to research the feasibility of developing an intelligent, natural-ventilation cooling controller that can determine and implement the most efficient strategy for pulling in outside air to reduce air conditioning costs in residential homes that will minimize air conditioning costs for homeowners. The greatest potential source of cooling energy in most California climates is when cool outdoor air is available to flush overheated buildings. In most California climate zones nighttime temperatures are usually quite comfortable. The controller's task is to know how much night-time air should be brought in to cool down the building's interior mass so that it can 'coast' comfortably through the next day, and not overcool so that heating is needed the following morning. This controller should also know if it is using more fan energy than it is recovering in cooling, or if wind-driven natural ventilation is available. Our studies have shown that the need for air conditioning can often be completely eliminated in many climates if the building is carefully designed and if a smart controller can be developed to harvest this resource.

Proposed Outcomes:

- Prototype ventilation cooling controller with control logic designed for the 16 climate zones in California.
- Feasibility assessment based on prototype performance testing performed in large-scale test cells.

Anticipated Benefits:

- Eliminate or reduce the need for air conditioning in CA climate zones that have cool nighttime temperatures.
- Achieve minimum energy savings of 100,000 MWh per year in CA if it eliminated the need for one air conditioner per 1000.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted
- EISG Program Administrator's Review of Draft Final Report in process.

SOLICITATION 99-02

Low Cost Microchannel Reformer for Hydrogen Production from Natural Gas

EISG Grant Number: 99-14

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Darby Makel (530) 895-2771

Organization: Makel Engineering, Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of fabricating prototype microchannel reformers for converting natural gas to hydrogen for use in fuel cells. Innovative fabrication strategies will be investigated and tested.

Proposed Outcomes:

- Two prototype reformers that employ different fabrication strategies.
- Performance results from prototype tests.
- Methodology for fabricating small, low-cost, scaleable, natural gas reformers.

Anticipated Benefits:

- Enable the mass production of low cost natural gas reformers, thus significantly reducing the manufacturing cost of integrated fuel cells.
- Enabling technology that would allow small residential and commercial fuel cells to operate from the abundant and inexpensive natural gas supplies in California.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

Feasibility of Solar Fired, Compressor Assisted Absorption Chillers

EISG Grant Number: 99-15

PIER Area: Building End-Use Efficiency

Principal Investigator: James Bergquam (916) 383-9425

Organization: Bergquam Energy

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of improving the performance and reducing the cost of solar heated absorption chillers by incorporating a small vapor compressor into the design. Candidate vapor compressors will be identified and tested. This project targets small-to medium-sized commercial buildings with cooling loads up to 100 tons.

Proposed Outcomes:

- An improved design for single and double effect solar heated absorption chillers that will reduce their operating temperatures below 140 degrees F and 250 degrees F respectively.
- Identify off-the-shelf compressors or specifications for a custom compressor that will perform the required function.

Anticipated Benefits:

- Reduce the cost of the systems by eliminating the need for high pressure components that are required for systems operating above 250 degrees F.
- Reduce system payback period from 8 years to less than 5 years.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

Energy Shaver – A Thermal Energy Storage Device for Air Conditioners

EISG Grant Number: 99-16

PIER Area: Building End-Use Efficiency

Principal Investigator: James Lester (970) 963-2517

Organization: Redstone Engineering Consulting Inc.

Grant Amount: \$74,695

Project Description: The purpose of this project is to research the feasibility of increasing the efficiency of residential air conditioners through the use of a phase change material (salt hydrate) to augment the cooling of the condensed Freon. A subscale prototype of the proposed heat exchanger will be fabricated and tested. The system will be designed as a retrofit package for existing air conditioning systems.

Proposed Outcomes:

- Mathematical model of the proposed air conditioning system to verify efficiency improvements.
- Design for an efficient, low cost heat exchanger capable of cooling the condensed Freon to 85 degrees F.

Anticipated Benefits:

- Increase the operating efficiency of residential air conditioners by up to 30 percent.
- Potential to reduce peak electric consumption in California through passive means by exploiting the large differential in day and night time temperatures that exists in the hottest regions of California and the Southwestern U.S.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

High Speed Light Activated On/Off Thyristor

EISG Grant Number: 99-17

PIER Area: Strategic Energy Research

Principal Investigator: David Giorgi (619) 452-8787

Organization: OptiSwitch Technology

Grant Amount: \$74,900

Project Description: The purpose of this project is to research the feasibility of developing an all-light controlled on/off thyristor power switch. A thyristor is an electronic device that conducts electricity in one direction only. This effort leverages prior development of a light activated switch capable only of turn-on that was developed for surge protection applications. This effort will add turn-off capability to the light activated switch thereby extending its potential use into a wide range of electrical devices- such as inverters, filters, pulse-width modulators, etc.- that can benefit from smaller, lighter and more efficient high-speed power switches. Preliminary physical tests will be performed to demonstrate feasibility.

Proposed Outcomes:

- Using 2D-simulation code, a mathematical model will be developed of the light controlled thyristor.
- Specifications for required laser light source.
- Process steps for device fabrication.

Anticipated Benefits:

- Increase turn-off current density capability over existing

thyristor switches by a factor of four to 100 A/cm² (amps per square centimeter) while maintaining a 1 μ s (micro-second) turn-on time.

- This technology will enable power switches to be made smaller and lighter than existing switches, which should reduce manufacturing costs.
- Light activated switches are more reliable because they are not susceptible to faulty triggering from electrical noise.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

SOLICITATION 99-01

Electrosynthesis of Device Quality Semiconductor Films

EISG Grant Number: 99-01

PIER Area: Renewable Energy Technologies

Principal Investigator: Shalini Menezes (805) 492-9814

Organization: InterPhases Research

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of an innovative electrochemical process that could be used in fabricating high quality thin films for copper indium diselenide photovoltaic (PV) modules. The process is designed to be simpler and more cost effective than current thin-film PV processes and is capable of being scaled up to large-area modules for manufacturing purposes.

Proposed Outcomes:

- Methodology for synthesizing consistent high quality copper selenide (CuSe) films using a new electrodeposition process.
- Precise control of film growth by regulating cycles using a specially designed diffusion layer deposition apparatus.

Anticipated Benefits:

- Reduce the cost of manufacturing large-area copper indium diselenide (CIS) PV modules.
- Eliminate expensive vacuum processing and vapor deposition procedure.
- Thin-film PV technologies, such as copper indium diselenide, are projected to reduce PV manufacturing costs by 75 percent.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget

- Final Report completed
- Feasibility Analysis Report completed

Ventilation Measurement and Control

EISG Grant Number: 99-02

PIER Area: Building End-Use Efficiency

Principal Investigator: Clifford Federspiel (510) 526-7484

Organization: Federspiel Controls

Grant Amount: \$74,970

Project Description: The purpose of this project is to research the feasibility of producing a prototype, air flow measurement device for ventilation systems that is energy efficient, accurate, cost effective and maintenance free. This technology will be used to measure and control outdoor intake airflow rates, exhaust airflow rates and the airflow rates supplied to occupied spaces in buildings.

Proposed Outcomes:

- Prototype air flow device capable of measuring actual air flow within +/- 10 percent over the full range of operating conditions.
- Control logic and methodology for fan pressure resetting and demand-controlled ventilation.

Anticipated Benefits:

- Design that is less prone to fouling, is sensitive to variations in airflow velocity distribution within the duct and requires less maintenance.
- Reduce the cost to manufacture and install using low cost components and eliminate the need for a separate duct section dedicated to airflow measurement.
- Potential to reduce energy consumption in California by.055 quads (1 quad = 2.93 X 10¹² kWh), of which.035 quads is

related to reduced electrical consumption equivalent to \$326 million per year.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed
- Feasibility Analysis Report completed

Control of On-Off Equipment in Buildings

EISG Grant Number: 99-03

PIER Area: Building End-Use Efficiency

Principal Investigator: David Auslander (510) 642-4930

Organization: UC Berkeley

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of using new control strategy for the operation of On-Off HVAC systems and subsystems within commercial buildings. The control logic would be designed to minimize start-stop cycling frequency while ensuring that the variation in the process remains within acceptable limits.

Proposed Outcomes:

- Computer simulation that establishes the energy efficiency, temperature variation and maintenance impact of the proposed control strategy that incorporates state transition logic of multi-stage HVAC equipment and capacity control logic.
- Performance comparison of the new control logic with existing level-crossing logic.

Anticipated Benefits:

- Increase the operating efficiency and reduce maintenance costs of HVAC and refrigeration systems through improved control logic that reduces the cycling frequency.
- Potential to reduce energy consumption in California by .15 quads (1 quad = 2.93 X 10¹² kWh), of which .084 quads would be related to reduced electrical consumption equivalent to \$1.97 billion per year.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

Process for Converting Sewage Sludge and Municipal Solid Wastes to Clean Fuels

EISG Grant Number: 99-04

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Radon Tolman (505) 982-9912

Organization: Environmental Energy Systems Inc.

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of producing hydrogen and other clean fuels from wet biomass, sewage sludge and municipal solid wastes. The system would use the output of an aerobic (oxygen present) digester in combination with an innovative heat recovery steam generator that uses a water gasification process which is capable of accepting solutions of minerals and metals in slurries and emulsions without corrosion and deposition on heat transfer surfaces.

Proposed Outcomes:

- Quantify and analyze the liquids, gases and solid residues produced from a bench-scale prototype using the output of an aerobic digester as the feedstock.
- Quantify the fuel values and requirements for additional cleaning / treatment of the resulting fuels for use in gas turbines for electric generation.
- Assess the mass and energy balance, system optimization and economic feasibility.

Anticipated Benefits:

- Achieve 40 percent thermal efficiency in processing wet biomass sludge into electric power.
- Reduce quantity of secondary waste requiring landfill disposal. A typical sewage treatment plant- such as the plant in Encina, California- produces 90-100 metric tons per day of secondary waste and pays \$24 per wet ton for landfill disposal.
- Reduce need for landfill leachate collection and treatment and landfill gas recovery.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed
- Feasibility Analysis Report completed

New Generation Thermoelectric Materials for Power Generation and Refrigeration

EISG Grant Number: 99-05

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Angelica Stacy (510) 642-3450
Organization: UC Berkeley
Grant Amount: \$74,994

Project Description: The purpose of this project is to research the feasibility of fabricating a thermoelectric material into a layer of microscopic unidirectional wires that are oriented perpendicular to the first layer which, in theory, should improve the conversion efficiency of generating electricity directly from heat. Thermoelectric power generators are produced by joining two thermoelectric materials with opposite charge carriers and applying heat to one side. The thermoelectric fabrication be accomplished through the precise, electrodeposition of Cobalt Antimonide (CoSb₃) into a porous template. The objective is to produce a higher-efficiency thermoelectric material that can be used in power generation and refrigeration.

Proposed Outcomes:

- Optimized methodology for electrodeposition of CoSb₃ in a porous alumina template.
- Assessment of the thermoelectric properties of a fabricated array of CoSb₃ nanowires using electrodeposition.

Anticipated Benefits:

- Improve the efficiency of thermoelectric materials above the current state of the art by 10 percent.
- The advantages of thermoelectric power generation include: no emissions, no moving parts, quiet operation, and can operate from waste heat.
- Solution for stopping photosynthetic oxygen production during the hydrogen production phase, which is important, since the presence of oxygen prevents the formation of enzymes needed for the production of hydrogen.

Anticipated Benefits:

- Increase hydrogen production efficiency from the current 10 percent to 20 percent of the theoretical maximum.
- Establish of a commercially sustainable H₂ production methodology utilizing green algae and sunlight.

Project Status:

- 100% complete
- Completed behind Schedule
- Completed within budget
- Draft Final Report completed
- Draft Feasibility Analysis Report under review

Renewable Hydrogen Fuel Production by Microalgal Photosynthesis

EISG Grant Number: 99-06
PIER Area: Renewable Energy Technologies
Principal Investigator: Anastasios Melis (510) 642-8166
Organization: UC Berkeley
Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of increasing hydrogen production from the photosynthesis of algae. Three promising methodologies will be investigated: the effect of shifting the chemical equilibrium of the reaction, modifications to the growth media and the effect of diurnal cycles.

Proposed Outcomes:

- Optimized methodology for producing hydrogen from algae and sunlight.
- Solution for stopping photosynthetic oxygen production during the hydrogen production phase, which is important, since the presence of oxygen prevents the formation of enzymes needed for the production of hydrogen.

Anticipated Benefits:

- Increase hydrogen production efficiency from the current 10 percent to 20 percent of the theoretical maximum.
- Establish of a commercially sustainable H₂ production methodology utilizing green algae and sunlight.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed
- Feasibility Analysis Report under development

Roofing Tile for Natural Cooling

EISG Grant Number: 99-07
PIER Area: Building End-Use Efficiency
Principal Investigator: Tom Dinwoodie (510) 540-0550 x227
Organization: PowerLight Corporation
Grant Amount: \$74,885

Project Description: The purpose of this project is to research the feasibility of an innovative residential roofing tile that will significantly reduce roof deck temperatures through passive convection and reflective means. Computer modeling and simulations will be performed and roof tile prototypes will be fabricated and tested.

Proposed Outcomes:

- Optimized roof tile design that possesses the desired

conduction, radiation and convection heat transfer properties.

- Prototype roof tile capable of maintaining roof deck temperature at or below ambient temperature.

Anticipated Benefits:

- Projected annual energy savings of \$24-\$490 for a 2,000 sq-ft home depending on home construction and location.
- May permit the sealing of attic spaces in locations with high humidity for better moisture control.
- Tile design may be integrated with PV for added energy savings.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted
- Revised Draft Final Report has been submitted.

Modeling Greenhouse Temperature for Energy Efficient Production

EISG Grant Number: 99-08

PIER Area: Industrial/Agriculture /Water End-Use Efficiency

Principal Investigator: J. Heinrich Lieth (530) 752-7189

Organization: UC Davis

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of creating models that accurately predict the effect of varying energy-related climate conditions on the growth of different hothouse plants. The models could then be used in computerized controls that allow HVAC systems to operate only when required to optimize plant growth or prevent plant damage.

Proposed Outcomes:

- A dynamic greenhouse energy model that quantifies the efficiency of external energy input under various climatic scenarios.
- Strategies for greenhouse temperature control that create satisfactory crop value with minimal energy cost.

Anticipated Benefits:

- Improve energy efficiency of greenhouse operations by 20 percent.
- Improve the competitive position of domestic greenhouses that are experiencing increased competition from overseas.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

A New Gas Turbine Engine Concept for Electricity Generation with Increased Efficiency and Power

EISG Grant Number: 99-09

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: W. A. Sirignano (949) 824-3700

Organization: UC Irvine

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of an innovative gas turbine design that extends combustion into the turbine sections. This design process has the potential to significantly increase thermal efficiency and specific power output of gas turbines. This project will include a detailed cycle analysis to include turbine inlet temperature, pressure ratio and power distribution in the turbine stages and aerothermodynamic and combustion analysis on the flow through the turbine blades.

Proposed Outcomes:

- Optimized gas turbine design configuration.
- Identify technological obstacles that need to be overcome to advance the concept to the next level.

Anticipated Benefits:

- Increase thermal efficiency of gas turbines to 65 percent, a 15-20 percent increase over conventional engines used for electrical generation. This represents a significant increase in the percentage of the heat energy in the natural gas fuel that is converted to electrical energy.
- Increase the specific power by 100 percent over conventional engines, which allows engines to be built smaller resulting in lower capital costs.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Feasibility Analysis is Initiated

Development and Characterization of Improved Solid State Dye-Sensitized Nanocrystalline Solar Cells

EISG Grant Number: 99-10

PIER Area: Renewable Energy Technologies

Principal Investigator: Jin Zhang (831) 459-3776

Organization: UC Santa Cruz

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of two innovations to reduce the cost and improve the reliability and maintainability of nanocrystalline dye-sensitized solar cells. In this type of solar cell, sunlight is absorbed by the dye, which transfers electrons to titanium oxide particles that pass the electrons to the conductive layer on the glass. A liquid solution (electrolyte/redox mediator) is used to regenerate the dye. Four promising transparent conjugated polymers will be fabricated and tested. This project will investigate:

- use of a solid polymer film in place of the liquid electrolyte/redox mediator; and
- use of natural, water-based non-toxic pigments.

Proposed Outcomes:

- Prototype nanocrystalline dye-sensitized solar cell built with a solid polymer film in place of liquid electrolyte/redox and a natural water-based pigment.
- Identify technological obstacles that need to be overcome to advance concept to the next level.

Anticipated Benefits:

- Increase the operational life of nanocrystalline dye-sensitized solar cells beyond the current limit of 7000 hours. Limitation is due to the instability of the liquid electrolyte/redox media.
- Advantage of nanocrystalline dye-sensitized solar cells is that they can be fabricated using inexpensive materials and little specialized equipment making them attractive to both industrialized and developing nations.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report has been submitted
- Feasibility Analysis Report has been drafted

Actively Controlled Jet Injection in Gas Turbine Engines

EISG Grant Number: 99-11

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Ann Karagozian (310) 825-5653

Organization: UC Los Angeles

Grant Amount: \$74,899

Project Description: The purpose of this project is to research the feasibility of using actively controlled dilution air jets that deliver pulsed air perpendicular to the intake air flow in the primary zone of a gas turbine's burner to rapidly produce a lean mixture. Dilution air jets are used in gas turbines for temperature control and NO_x reduction through air-fuel mixture ratio control. This project builds upon prior work that modeled pulsed transverse jet flow, and will develop control strategies based on simulations followed by experimental validation using a bench-scale combustor.

Proposed Outcomes:

- Optimal open and closed loop control strategies for pulsed transverse dilution jets to achieve maximum reduction of NO_x emissions.
- Combustor design specifications for incorporating pulsed air jets, actuators and sensors.

Anticipated Benefits:

- Reduce NO_x emissions in gas turbines 50 percent by maintaining a constant, lean air-fuel mixture.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed and is under review
- Feasibility Analysis is Initiated

Omni Smartpump

EISG Grant Number: 99-12

PIER Area: Industrial/Agriculture/Water End-Use Efficiency

Principal Investigator: B. C. MacDonald (707) 937-4352

Organization: Omni Instruments

Grant Amount: \$75,000

Project Description: The purpose of this project is to research the feasibility of using prototype, high-efficiency, variable-speed electric motors with programmable control electronics and pressure sensors to more energy efficiently provide constant optimal pressure to a closed loop drip irrigation system. The use of a standard single speed motor running at full power wastes electrical energy when it delivers either too much or too little water pressure. This project will fabricate and bench test 3-4 prototype systems in the 2 horsepower power range that incorporate variable speed AC

and DC motors, digital controllers, pump heads and external sensors. One or more of the designs will be field-tested under real world conditions.

Proposed Outcomes:

- Prototype variable speed irrigation pump optimized for drip irrigation applications.
- Compare the energy efficiency of prototype systems with conventional irrigation pumping systems.
- Identify the technological obstacles to scaling up large AC motors for variable speed operation for use in drip irrigation.

Anticipated Benefits:

- Improve the energy efficiency and cost of drip irrigation pumping systems by eliminating the need for a separate pressure tank while maintaining a constant optimal water pressure.
- Motor control technology can be scaled up to include large AC motors used in large-scale irrigation operations.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Draft Final Report completed
- Draft Feasibility Analysis Report Completed
- Final Report Revisions in process

Improved Operational Turndown of an Ultra-Low Emission Gas Turbine Combustor

EISG Grant Number: 99-13

PIER Area: Environmentally Preferred Advanced Generation

Principal Investigator: Scott Smith (408) 727-8282

Organization: Alzeta Corporation

Grant Amount: \$74,103

Project Description: The purpose of this project is to research the feasibility of a new, lean-premix gas turbine combustor design that permits precise local control of the air-to-fuel ratio which improves the operating range of the combustor and significantly reduces NO_x emissions. The project includes fabrication and testing of up to four prototype combustor configurations and the development and testing of potential control strategies.

Proposed Outcomes:

- Prototype lean-premix gas turbine combustor capable of meeting targeted emissions levels.
- Optimized fuel/air control strategy for prototype combustor.

Anticipated Benefits:

- Reduce NO_x, CO and hydrocarbon emissions in lean-premixed gas turbine combustors to 5 ppm, 10 ppm and 10 ppm, respectively.
- California relies heavily on gas turbines for electric generation and low emission gas turbines are expected to play a major role in distributed generation.

Project Status:

- 100% complete
- Completed on Schedule
- Completed within budget
- Final Report completed
- Feasibility Analysis Report completed

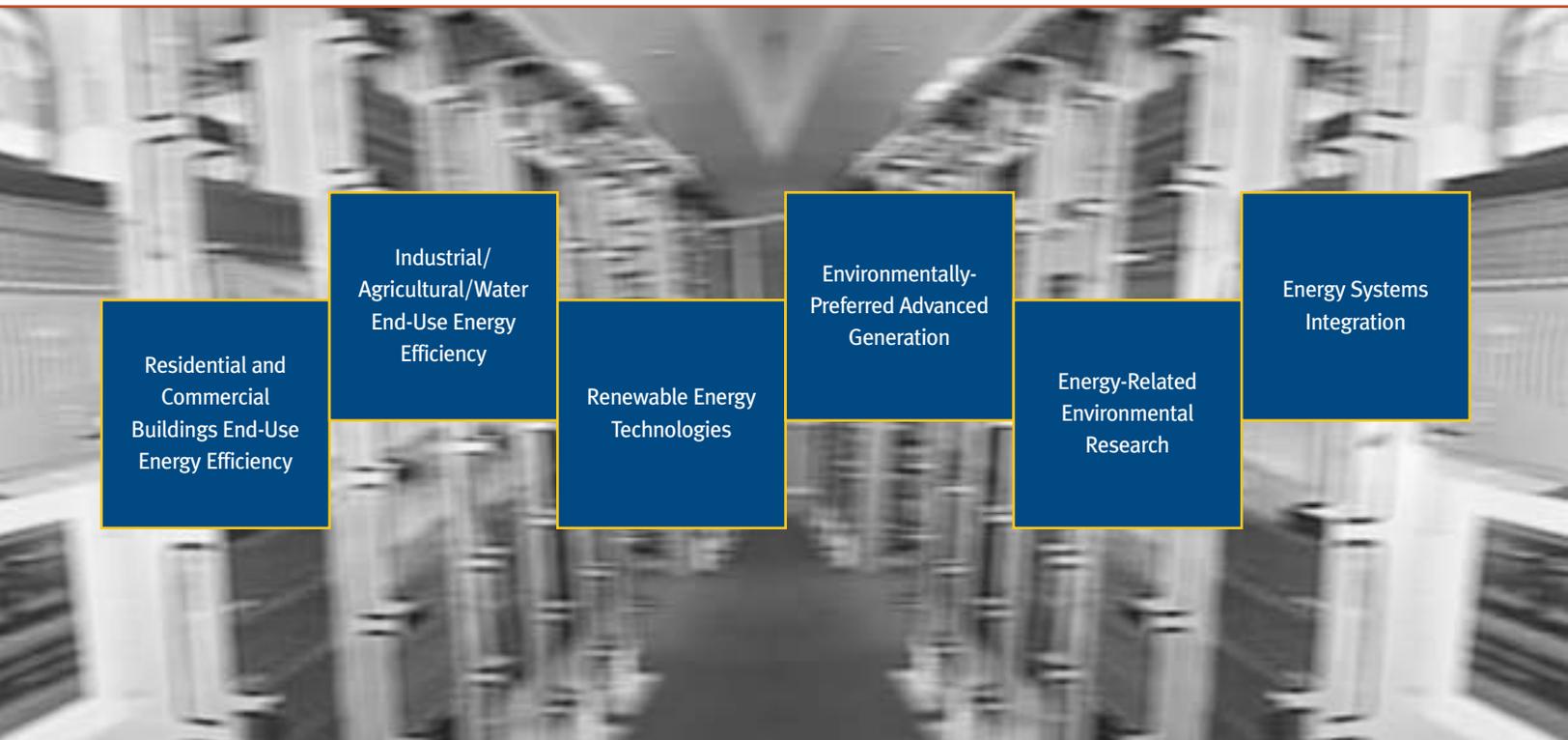


CALIFORNIA ENERGY COMMISSION

1516 Ninth Street, MS 43 | Sacramento, California 95814

www.energy.ca.gov/pier

A N N U A L R E P O R T 2 0 0 2



C A L I F O R N I A E N E R G Y C O M M I S S I O N

