

CALIFORNIA  
ENERGY  
COMMISSION

**2004 Annual Review of the PIER Program  
Volume 4 – Renewable Technologies  
Project Summaries**

**STAFF REPORT**

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## **REN Multi-Year Projects Started in 2004**

## California Solar Energy Collaboration

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-028

**Contractor:** University of California, Davis

**Project Amount:** \$400,000

**Contractor Project Manager:** Bruce White (530) 752-6451

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

**Status:** Active

### Project Description:

Passage of California's Renewable Portfolio Standard (RPS) places significantly increased emphasis on the use of renewable resources to meet the State's electricity demands. In addition, transmission constraints will place increasing pressure on meeting those demands directly at load centers where possible. Due to their inherent ability to track coincident peak demand during summer hours and to be located directly at the load centers, solar resources offer the potential to help reduce peak demand without incurring additional transmission growth. Moreover, California has tremendous solar resources that if cost-effectively harnessed could provide substantial renewable capacity and electricity delivery to the State's grid. Governor Schwarzenegger's interest in having photovoltaic systems installed in fifty percent of new home development starting in 2005 further highlights the need for the State to examine new and advanced solar developments and approaches.

This WA will establish and administer a California Solar Energy Collaborative that will help coordinate solar energy research, development and deployment activities beneficial to the State. It will provide a forum to meet and discuss ways to accelerate solar energy beneficial to California for leading experts from California's solar energy industry, electricity utilities and service providers, federal energy labs, affected and interested State and local representatives, the environmental community, California's building industry, and the academic sector. The California Solar Energy Collaborative will also provide the Commission with ready access to solar energy expertise to help achieve timely review and implementation of policy concepts and proposed system and technology innovations. Additional California Solar Energy Collaborative goals include initiating activities under several of the primary topical areas including research, development, demonstration, deployment, public outreach, policy, and standards. California Solar Energy Collaborative activities will be closely coordinated with Commission departments.

### This project supports the PIER Program objectives of:

- Improving California's electricity diversity, increasing the cost effectiveness of renewable energy technologies to help lower electricity costs, and reducing environmental risks associated with electricity generation by establishing and administering a California Solar Energy Collaborative that will help coordinate solar energy research, development and deployment activities beneficial to the State.
- Maximizing "market connection" for project research results by actively interacting with technology implementers in the solar, electricity utility and the building industries.

### Proposed Outcomes:

The Solar Energy Collaborative is intended to be an ongoing activity supported by a variety of groups. To reach the goals outlined above the technical objectives for the first year of the project consist of the following:

1. Establish a Collaborative Advisory Board and an Executive Committee.
2. Prepare white papers that identify the extent to which solar resources can play a role in meeting California's RPS and Energy Action Plan goals. The white papers will address

the costs and benefits associated with meeting various RPS targets, and any recommendations for accelerating the role of solar resources within the adopted portfolio. It will also specifically examine various approaches to address the administration's goal of implementing photovoltaic systems on fifty percent of new homes.

3. Establish a centralized clearing house of information and expertise regarding solar energy related questions and activities in the State.
4. Develop a web-based Solar Performance Reporting System (SPRS) that provides open and transparent information on the performance of solar installations in the State, and provides case studies for evaluating the performance, cost, impacts and benefits of solar installations.
5. Develop a white paper on leapfrog and disruptive technologies, for example nanotechnology-based photovoltaics, which could significantly change the evolution of solar energy in California.
6. Perform technical assistance in an advisory capacity for changes in California's solar industry activities.

**Project Status:**

The project is currently on hold.

## California Wind Energy Collaborative

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-017

**Contractor:** University of California, Davis

**Subcontractors:** Dynamid Design Engineering, Inc. : Davis Consulting

**Project Amount:** \$2,622,869

**Contractor Project Manager:** C. Van Dam (530) 752-7741

**Commission Contract Manager:** Mike Kane (916) 654-7119

**Status:** Active

### Project Description:

California has the largest developed wind industry of any state in the nation with a total installed wind energy generating capacity nearing 2000 megawatts. In addition, wind generated electricity provides close to 4 billion kilowatt-hours of electricity to California ratepayers every year. California's wind energy resources could provide up to four times the present wind generating capacity and help address electricity problems facing the State. Successfully developing additional wind resources so that they represent a valuable, clean, reliable and affordable part of the State's electricity system requires coordination among wind energy developers, environmental groups, electricity suppliers and government representatives.

The importance of wind energy has long been recognized by the California Energy Commission, which supports research and development in renewable energy including wind through its PIER Program. The University of California, and particularly UC Davis, has a history of wind energy related efforts dating back approximately twenty years. Several of its faculty and students have been working with researchers and engineers in industry, national laboratories, and other universities on a wide range of wind energy related problems.

Within California, wind energy development is conducted by an international set of industry players who compete against one another making coordination at the industry level difficult. Government involvement in wind energy development also lacks a coordinated approach between industry participants and government agencies. While the Energy Commission supports wind energy development through the Renewable Energy Program and the PIER Renewables Program, neither program has established a forum for ongoing coordination of wind energy development in California. Outside of California, the AWEA has traditionally acted as a clearinghouse of information about wind energy activities and sponsored wind energy conferences covering a variety of wind energy related topics. Similarly, the Department of Energy (through the National Wind Energy Program) and the NREL have directed wind energy development efforts. However, the AWEA, DOE and NREL efforts all have a national perspective rather than a California specific perspective.

Based on input from the wind industry, the PIER program determined a need to establish the California Wind Energy Collaborative (CWEC) and address specific tasks to support the California wind industry. In response, CWEC was established in February 2002. This work authorization continues Commission funding of and expands on the work of the CWEC, which was originally established under 500-00-029.

### This project supports the PIER Program objectives of:

- Improving the cost effectiveness of wind energy technologies and reducing environmental risks and cost of California electricity by continuing to fund the California Wind Energy Collaborative.

- Maximizing "market connection" for project research results by actively interacting with the wind industry and other interested parties.

**Proposed Outcomes:**

1. Provide a forum for coordinating development of wind energy systems beneficial to California's unique topology.
2. Provide expertise to the Commission to help supplement and support wind energy development programs specific to California.
  - Continue to address penetration and integration issues respecting California's Renewables Portfolio Standards and Integrated Energy Policy Report (IEPR).
3. Support the wind industry by maintaining an electronic wind database, developing a wind energy technician training plan, preparing white papers on current industry issues, and support wind verification efforts and measurements in California.

**Project Status:**

This project is active and on schedule.

Work performed in 2004 includes:

- 2004 California Wind Energy Collaborative Forum held in Palm Springs in December.
- Participated in two Energy Commission public workshops relating to Phases I and III of the RPS cost integration methodology and analysis.
- Produced white papers targeted to address wind industry permitting concerns, (blade throw setbacks, FAA lighting, etc.).
- Upgraded electronic WPRS to include archival data to 1985.
- Developed a training program for small wind energy technicians to offer as a one day course starting in 2005 or 2006.

An amendment to augment this work authorization for \$1.46M and 18-month time extension is currently pending. The purpose of the augmentation/extension is to:

- Continue normal CWEC activities through September, 2006.
- Fund and coordinate a multi-member intermittency study group to investigate increasing levels of intermittent energy penetration into the California grid and leveraging the lessons learned in Europe and Asia.
- Support the Tehachapi Working Group in applying the "Cost of Integrating Renewables" methodology into their efforts.

## Development and Demonstration of 50 kW Small Modular Biopower System

**Contract #:** 500-03-020

**Contractor:** Community Power Corporation

**Contract Amount:** \$725,000

**Match Amount:** \$420,000

**Contractor Project Manager:** Robb Walt (303) 933-3135

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Active

### **Project Description:**

The overall goal of this Agreement is to design, develop and demonstrate a 50 kilowatt (kW) modular gasification system for grid interconnection, and combined heat and power using forest residue. The biopower system will be located at the Siskiyou Opportunity Center in Mt. Shasta, and will use wood waste from the Opportunity Center as well as the forest biomass residue. This new agreement will continue the development and advances of the previous PIER supported 12 ½ kW small modular biopower (SMB) development program.

The recent, successful, Commission cost-share funded SMB technology demonstration project with the Community Power Corporation and the Hoopa Valley Tribe was a first step introducing SMB to the State of California. The primary goal of the project was to demonstrate technical and operational capability of a prototype, 12 ½ kW SMB system. This project builds on the success of the pilot project (Commission Contract 500-99-029).

During 2002, the Contractor and the Hoopa Valley Tribe operated a SMB system rated at 12 ½ kW to provide power and heat to a greenhouse the Hoopa Valley Tribe used to support their sustainable forestry business at the Tsemeta Forest Regeneration Complex, Hoopa, California. The project successfully demonstrated that a prototype SMB system could use waste forest slash and thinnings to provide utility grade power to the complex. The project also provided heat to maintain seedling bed temperatures. The SMB system was successfully connected to the PG&E grid.

The first prototype SMB system successfully met project objectives. However, further development of the prototype technology and extended on-site testing is needed to meet the demands of the market for distributed generation systems in California.

The specific long-term economic/cost objectives for the 50 kW power system are as follows:

1. Achieve a capital cost of \$1,750 per kW.
2. Achieve an electricity cost of less than 10 cents per kWh.
3. Achieve a heat cost of less than \$1.00 per therm.

### **This project supports the PIER Program objectives of:**

- Improving the cost competitiveness of the biomass energy conversion technologies and reducing environmental risks and costs of California's electricity by designing, developing and demonstrating a 50 kilowatt (kW) modular gasification system for grid interconnection, and combined heat and power using forest residue.
- Improving the reliability, quality and sufficiency of California's electricity by adding new "green" distributed generation capacity.

- Addressing important research, development, and demonstration gaps by responding to customer demand for a fully automatic, environmentally certified, 50 kilowatt electric (kW<sub>e</sub>) biopower system designed for continuous grid-tied operation in California.

**Proposed Outcomes:**

The specific technical objectives are:

1. Provide up to 50 kW<sub>e</sub> and 80 kilowatts of thermal power (kW<sub>t</sub>) power to the proposed on-site loads.
2. Provide 3 phase power in parallel with the grid in net metering mode so as to displace retail sales and achieve economic advantage for a distributed power system.
3. Operate with no more than one operator by achieving full automation of start-up, operation, monitoring, and shutdown.
4. Provide 50 kW<sub>e</sub> power with a turndown range of 10 to 1 using forest residue as the renewable fuel source.
5. Operate SMB continuously for six days.

**Demonstrate combined heat and power capabilities of the biopower system by capturing waste heat from the gas production and power generation modules for a period of 24 months, as follows:**

- For the first twelve months of operation, the system will have 60% availability.
  - For the second twelve months, the system will have 80% availability.
6. Achieve at least an increase of 20% in the electrical efficiency of the 50 kW system when compared to the previous 12 ½ kW system.
  7. Achieve at least an increase of 10% in the combined heat and power efficiency of the 50 kW system when compared to the previous 12 ½ kW system.
  8. At peak power of 50 kW, the SMB system shall meet or exceed California Air Resources Board's emission standards (including nitrogen oxides, volatile organic compounds, and particulate matter) for a combined heat and power distributed generation system.

**Project Status:**

- A kick off meeting was held on March 30, 2004 to discuss administrative and technical requirements and expectations.
- Task 2.0 System and Component Design for 50kW SMB:
  - Contractor has completed design and fabrication of the SMB components.
  - Shakedown testing of the SMB components has been completed.
  - Contractor is now shop testing the SMB.

The project is on schedule and is expected to be completed by December 2007.

## **Development and Demonstration of A Distributed Biogas Energy System Utilizing Organic Solid Wastes**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-029

**Contractor:** University of California, Davis

**Subcontractors:** Grand Central Recycling & Transfer Station Inc. : Norcal Waste Systems Inc. : Onsite Power Systems

**Project Amount:** \$995,763

**Match Amount:** \$3,020,361

**Contractor Project Manager:** Ruihong Zhang (530) 754-9530

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

**Status:** Active

### **Project Description:**

This proposed project from UC Davis will scale-up, test, and demonstrate a new anaerobic digestion technology capable of processing high solids and is called the Anaerobic Phased Solids Digester System (APS-Digester) (U.S. patent 6,342,378). The APS-Digester technology was developed at University of California, Davis and is an advanced technology with innovative design features that optimize the bacterial degradation of organic wastes (i.e., green waste, food waste and manure), provide efficient material handling solutions, and combine the favorable features of both batch and continuous operations in a single biological system. This APS digester system has been proven to be reliable and stable at the laboratory level. However, the material handling issues, actual waste stream characteristics, digester performance at large scale, digester residual material characteristics and net value are yet to be addressed. The testing and analyzing of the APS-Digester at scales larger than the bench-scale are needed prior to full-scale system commercialization.

A pilot scale APS-Digester of 3 tons per day capacity will be developed and tested at UC Davis and a full-scale demonstration APS-Digester of 25 tons per day capacity will be developed and tested at Grand Central Recycling & Transfer Station in the City of Industry, Orange County, California, using recycled green and food wastes. The plan for developing a commercial anaerobic digestion facility in Northern California will also be developed from collaboration with Norcal Waste Systems. The results of this project will help transfer the APS-Digester from the research laboratory to the commercial entities and could help lead to the development of large, commercial anaerobic digestion facilities in the State. If successfully commercialized, these facilities would produce distributed, renewable energy from various organic wastes with multiple environmental and economic benefits to the public.

The overall goal of this project is to prove the APS-Digester, in conjunction with a clean burn engine-generator, as an environmentally sound, cost-effective distributed energy system capable of degrading high solid wastes (food residues, community green wastes, and agricultural byproducts) while producing renewable energy, soil amendments and fiber products.

### **This project supports the PIER Program objectives of:**

- Improving the reliability and quality of California's electricity by developing distributed power generation systems.
- Improving the energy cost/value of California's electricity by providing competitively priced renewable energy generation capacity to meet the "green" electricity portfolio standard while meeting organic waste landfill diversion regulations.

**Proposed Outcomes:**

Specific technical outcomes:

1. Demonstrate a 3-ton per day pilot APS-Digester system capable of degrading high solids organic materials.
2. Demonstrate a methane (CH<sub>4</sub>) generation rate of 6 cubic feet (ft<sup>3</sup>) CH<sub>4</sub>/dry pound mass (lbm) VS volatile solid fed.
3. Demonstrate a 20 kilowatt (kW), grid-tied, digester-microturbine generator combination capable of providing 432 kWh/day electricity at 90% availability, while meeting current California Air Resources Board (CARB) standards.
4. Design and construct a 25-ton per day commercial APS-Digester system, with gas compression technology, to produce 450 kW of peak electricity, at 90% availability.
5. Operate and monitor the performance of the commercial demonstration system and perform energy, environmental, and economic analysis.
6. Demonstrate a full scale Wakesha biogas-fueled generator with heat rate of 8,000 British thermal units (Btu)/kilowatt hours (kWh), and nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO) and volatile organic compound (VOC) emissions of 0.017, 0.024, and .005 pounds (lb)/one million British thermal units (mmbtu), respectively, meeting the 2007 CARB emissions standards.

Specific economic outcomes:

1. Demonstrate a final cost of electricity (COE) below the stretch goal of \$0.04/kWh for a full-scale commercial system.
2. Demonstrate an electrical generation system capital cost, including gas recovery system, of \$3,000/kW.
3. Demonstrate a commercial digester-generator capacity factor of 90%.
4. Show a simple system payback of less than 6 years.
5. Prove the economic value of residual materials as soil amendments and fertilizer.

**Project Status:**

- The project is ongoing. A kickoff meeting for this project was held on June 28, 2004.
- The draft pilot plant digester design and test plan was completed and reviewed by the Commission Project Manager. The Contractor is in the process of addressing and incorporating comments for the Final Plant Digester Design and Test Plan Report.
- Good progress (i.e., around 60% complete) has been made in the fabrication of various parts of the digester system.

## Feasibility Study of PV Breakthroughs

**Contract #:** 500-02-014 **Work Authorization #:** E2I-WA-113

**Contractor:** Electricity Innovation Institute

**Project Amount:** \$268,000

**Contractor Project Manager:** Terry Peterson (650) 855-2594

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

**Status:** Active

### Project Description:

For the past 25 years, photovoltaic (PV) installed capacity has rapidly grown and its price has steadily declined. If these historic trends of technology and market development can be maintained, it is likely that PV will contribute up to about 10% of new U.S. capacity by 25 years from today but still require subsidies to compete economically with other energy sources for widespread adoption as a conventional means of generation. In lieu of significant cost reductions in the cost of PV systems, the cost-effective marketplace for PV will be limited to applications where its output directly displaces kilowatt-hours sold at retail rates that include costs of transmission, distribution, and system maintenance. The intent of this study is to investigate significant cost reductions in PV to enable widespread adoption of both small-scale and central facility applications.

This feasibility study will assess the technical options, rationale, and likelihood of success of such long-range collaborative research in significantly advancing the commercial competitive-ness of PV technology within the next 10 to 20 years. It will also consider the benefits of alternative actions, including that of not participating in any research, development and demonstration to advance PV technology within California.

### This project supports the PIER Program objective of:

- Improving the reliability, quality, and sufficiency of California's electricity by addressing important research, development and demonstration gaps by investigating significant cost reductions in solar PV that would result in widespread adoptions of PV in California.

### Proposed Outcome:

1. Identify the specific program goals, elements, procedures, participants' timeframes and costs associated with pursuing research into obtaining significant PV cost reductions via breakthrough research.

### Project Status:

The project is expected to be completed by December 2005.

## Renewable Technology Strategic Information (Program #84A)

**Contract #:** 500-02-028 **Project #:** 22

**Contractor:** Electric Power Research Institute (EPRI)

**Project Amount:** \$45,000

**Contractor Project Manager:** Chuck McGowin (650) 855-2445

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

**Status:** Active

### Project Description:

Technology developers continue to improve the efficiency and cost performance of renewable technologies. As a result, renewable technology status, performance, cost, installed capacity, markets, and other characteristics continue to change rapidly. This project maintains an up-to-date and objective strategic assessment of renewable technology for use in strategic planning and decision making. In addition to the EPRI *Renewable Energy Technical Assessment Guide (TAG-RE)*, which was first issued in 2000 and is updated annually; project deliverables include the *Renewable Energy Calculation Tools*, *Renewable Energy Strategic Service*, the International Database of Renewable Energy Requirements, a report on *Renewable Energy Requirement Status and Compliance Strategies*, and the *EPRI Renewable Energy Strategy Interest Group (RESIG)*.

### This project supports the PIER Program objective of:

- Providing greater choices for California consumers by supporting compilation and updates of renewable technology development and deployment information.

### Proposed Outcomes:

1. Produce a status report and regularly issued updates that describe renewable technology status including: performance, cost, installed capacity, and markets.
2. Update the 2003 Renewable Energy Calculation Tools that estimate performance and cost of wind, solar photovoltaic, and biomass power generation for user-specified cases.
3. Provide Renewable Energy Strategic Service, including updates of the EPRI Renewable Energy Brochure and Slide Show, eMedia Renewable Energy Update newsletters, Strategic Reports, Perspectives, and the annual Outlook Conference.
4. Update the International Database of Renewable Energy Requirements.
5. Produce a technical report on status of renewable portfolio standards and other renewable energy requirements and compliance strategies.
6. Form the EPRI Renewable Energy Strategy Interest Group (RESIG).

### Actual Outcomes:

1. Produced the Technical Report, *Renewable Energy Technical Assessment Guide - TAG-RE: 2004*. EPRI Product # 1008366, December 2004.
2. Updated the 2003 Renewable Energy Calculation Tools and renamed them Renewables Calculator 2004.
3. *Provided Renewable Energy Strategic Service:*
  - a. Technical Update, *EPRI-Primen Renewable Energy Brochure*. EPRI Product # 1008370, December 2004.
  - b. Technical Update, *EPRI-Primen Renewable Energy Slide Show*. EPRI Product # 1008371, December 2004.
  - c. Service, *EPRI-Primen Renewable Energy Updates*. EPRI Product # E215109, December 2004.
  - d. Service, *EPRI-Primen Strategic Reports*. EPRI Product # E218069, December 2004.

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- e. Service, *EPRI-Primen Renewable Energy Outlook Conference*.  
EPRI, Product # E218072, May 2004.
- 4. Produced the Technical Update, *International Database of Renewable Energy Policy Initiatives*. EPRI Product # 1008373, December 2004.
- 5. Produced the Technical Report, *Renewable Energy Requirement Status and Compliance Strategies. 2004* EPRI Product # 1008374, December 2004.
- 6. Formed the EPRI RESIG.

### **Project Status:**

The project was completed in 2004. All scheduled products listed above were delivered by the date indicated. In addition a Renewable Energy Strategy Interest Group was held by EPRI in December 2004 at Palo Alto, CA.

## Strategic Value Analysis: GIS Development #2

**Contract #:** 500-04-004

**Contractor:** California Department of Forestry

**Subcontractors:** University of California, Berkeley

**Contract Amount:** \$650,000

**Contractor Project Manager:** Dean Cromwell (916) 445-4302

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Active

### Project Description:

The overall objective of this contract is to investigate the extent to which distributed renewable energy generation can help address current and prevent future problems with California's electricity system while simultaneously providing other significant public benefits. Other public benefits include improvements in air quality resulting from reduced open-field burning or agricultural residues, such as rice straw or orchard prunings. Another benefit is the reduction in wildfires associated with thinning of forest overgrowth in high-risk areas and use of the thinned materials to generate biomass-fueled electricity. Similarly, renewable distributed generation (DG) systems can create jobs in otherwise economically strained regions and spur development of new and inter-related businesses.

This project will also help determine the necessary performance, cost characteristics, and best locations for renewable power technologies that will be able to provide high strategic value to California's electricity system, while simultaneously providing high public benefits.

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 contract focuses primarily on using GIS tools to investigate the optimal locations for developing renewable DG systems based on renewable energy resources, detailed demographic, environmental, energy use information and results from the power flow analyses. It is a follow on to the CDF contract, 500-00-030. A third contract (with the McNeil, 500-00-031) focuses primarily on the use of power flow models to investigate the ability of renewable generation system to address electricity system problems. The transmission and distribution case studies that are developed under the contract with McNeil will be used in this contract including the power flow studies.

### This project supports the PIER Program objective of:

- This project meets the PIER goal of improving the reliability /quality of California's electricity by identifying where renewable DG systems can be located to help alleviate transmission and distribution (T&D) capacity and congestion problems in the State.

### Proposed Outcomes:

1. Use GIS tools to help determine optimal locations for developing renewable energy resources that can provide high value to California's electricity system as well as high public benefits. The Contractor will analyze information on renewable energy resources within California in combination with detailed demographic, environmental, energy use information and results from a power flow analysis program to achieve the overall technical objective. As compared to the CDF contract 500-00-030, this contract will provide information regarding renewable technologies that address RPS issues up until 2017.

Specific technical objectives of this contract are to:

2. Collect the 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 power flow analysis agreement.
3. Construct the 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.
4. Develop a windows based program at the CDF GIS Center (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.
5. Assist in establishing at least two case studies that provide representative and site specific analyses on the use of renewable DG systems to effectively and affordably address California electricity system problems.
6. Provide a written report and GIS-based maps depicting the key results obtained from the various Geographical Information System (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 for 2003, 2005, 2007, 2010, and 2017.

**Project Status:**

- The CDF contract related to the Strategic Value Analysis was signed by the General Services on August 31, 2004.
- Kick Off meeting was held to provide administrative and technical directions to the contractor.
- GIS hotspot maps have been prepared for 2005, 2007, 2010 and 2017.
- Contractor has completed work on the geothermal, wind and solar resources and is working on the forestry biomass resource assessment. Information from this project will also be used for the forthcoming Integrated Energy Policy Report (IEPR) proceedings.
- Megawatt (MW) injection maps for geothermal, wind and solar resources have been completed.

## Tracking the Sun for High Value Grid Electricity

**Contract #:** 500-03-035

**Contractor:** Powerlight Corporation

**Contract Amount:** \$1,214,389

**Match Amount:** \$1,700,573

**Contractor Project Manager:** Jonathan Botkin (510) 868-1260

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Active

### **Project Description:**

Single-axis trackers have been used productively in global photovoltaic (PV) systems since the early 1980's. The first large scale one-axis system – still operating – was a 1 megawatt (MW) system installed by the Sacramento Municipal Utility District (SMUD) at Rancho Seco in 1984. The obvious advantage of one-axis tracking is that 15% to 35% more energy is produced (increase determined by the specific site meteorology) compared to a stationary array using the same number of solar panels. Despite this advantage, single-axis trackers enjoyed relatively little market development until the late 1990's, because until that time, the best available commercialized technology was expensive and unreliable. The technology was expensive because separate motor/drive/controllers, or multiple 'passive' actuators, were required for each mechanical row of PV modules – adding roughly \$1/watt (W) installed cost and thus negating much of the benefit from increased energy production. As a result, customer demand was low. In 1999, Shingleton Design, LLC developed and introduced the MaxTracker – a low cost, high reliability single-axis tracker. This design was literally an application breakthrough. Using a simple mechanical linkage, a single motor/drive/controller could track up to 24 rows - more than 150 kilowatts (kW) of PV - at a time. With this technology, a customer can reliably track the sun for about the same cost as installing a fixed array. From 1999 to 2003, 6.7 MW of MaxTrackers were installed in the USA with over 2 MW installed in California alone. By contrast, less than four MW of all competing one-axis tracker designs have been installed over the twenty-year period of 1984-2003. In 2002 PowerLight, Corp. acquired ownership of the MaxTracker design which was subsequently renamed PowerTracker.

The PowerTracker structure, covered by US Patent No. 6058930 with additional patents pending, consists of high-strength steel torque tubes and support posts, an industrial drive system, controller bearings and fasteners. The parts count has been kept low to minimize inventory and procurement costs. For any given project, a combination of these components are arranged to the system specific characteristics, including the number of PV modules, the module type and size, the design wind speed, seismic and soil conditions, and the site configuration. Although the basic components are simple, many sites require custom engineering and design elements which add extra costs and delivery time.

While the PowerTracker is the leading single-axis tracker technology, there are still significant opportunities to improve the product and make it more viable to California energy consumers. The existing system is expensive and complex to install due to some non-standardized elements in the structural and electrical design. Maintenance costs are also high due to the relatively low reliability of the antiquated controller technology and the specialized skills required to adequately service these controllers. Furthermore, existing design software does not specifically address single-axis tracker parameters, which results in longer system design lead times. Capitalizing on these opportunities is the objective of this project.

**This project supports the PIER Program objectives of:**

- Improving the Reliability, Quality, and Sufficiency of California's Electricity by improving on existing PV tracking technology.
- Providing greater choices for California consumers by improving available solar technologies and making them more cost effective.

**Proposed Outcomes:**

The objectives of this project are to improve reliability and reduce installation time, maintenance time and capital costs of the PowerTracker system for utility and other large-scale commercial applications. The following specific performance measures for this project are:

1. Reduce PowerTracker life cycle (design, installation, construction, and operation) costs by 36%. This is equivalent to reducing fixed cost structure costs by 44%.
2. Reduce cycle time from system design to installation by 40%.
3. Increase the large-scale on-grid (>200 kW) market incrementally up to 25% to 30%.
4. Improve reliability and durability such that unscheduled maintenance will be reduced an estimated 65%.
5. Reduce steel waste stream by 70%, and show substantially less environmental impact for manufacturing, construction, and operations.
6. Improve single-axis PV tracking technology by increasing the quality while driving costs down which will create more renewable options for California energy consumers.

**Project Status:**

The Project is active and on schedule. The project is expected to be completed by December, 2006.

In the past year, PowerLight Corporation completed the following tasks:

- Initiated Task 2: Controller and Drive Improvements.
  - Deliverable 2.1, the Specifications of the Power Tracker were completed. This specification can be used as a basis for evaluation of various controller upgrades, or for completely new controller architecture.
  - Deliverable 2.2, the design of the installation tooling for improving the placement accuracy of the PowerTracker drive-unit was completed. The placement of the drive-unit is critical for preserving the proper geometric relation of the components and for ensuring proper operation of the tracking algorithm in the controller.
- Initiated Task 4: Next Generation Structural Design.
  - Deliverable 4.1, the Photovoltaic (PV) module mounting hardware prototypes for Power Tracker were completed. These hardware prototypes were developed to help reduce the overall cost and increase the reliability of the PowerTracker.
  - Deliverable 4.2, the design concepts for the tilted photovoltaic (PV) mounting hardware was completed.

## Wind Forecasting

**Contract #:** 500-02-014 **Work Authorization #:** E2I-WA-111

**Contractor:** Electricity Innovation Institute

**Subcontractors:** AWS Truewind, LLC : University of California, Davis

**Project Amount:** \$850,000

**Contractor Project Manager:** Chuck McGowin (650) 855-2445

**Commission Contract Manager:** Mike Kane (916) 654-7119

**Status:** Active

### Project Description:

California has very good wind resources for wind energy generation in several specific areas of the State. However, the intermittent and non-load conforming characteristics of the resource make wind energy a problematic resource to integrate and schedule into an electric power system. These issues are also financially excluding wind energy providers from participating in a competitive energy market. With the recently enacted Renewable Portfolio Standards (RPS) calling for 20% renewables in California generation mix by the year 2017, and accelerated to 2010 by the California Energy Action Plan, the problem will be exacerbated by increasing penetration of intermittent resources on the electricity network.

The California Energy Commission (CEC) identified wind energy forecasting as a high priority research need for integration of Renewable Energy back in 1999. Since then, the CEC and Electrical Power Research Institute (EPRI) have completed testing and development of two wind energy forecasting systems in parallel at two wind projects, a 90 megawatt (MW) wind project at Altamont Pass and a 66.6 MW project at San Geronio Pass (EPRI-CEC Reports 1007338 and 1007339, March and July 2003). The experience gained and results from that research project laid the foundation for the California Independent System Operator (CA ISO) to begin investigating short-term wind energy forecasting algorithms.

In its Participating Intermittent Resources Program (PIRP), the CA ISO intends to incorporate these resources into the market in ways that do not impose significant costs on other market participants, e.g. the costs of additional spinning reserve, voltage regulation and other ancillary services required to support intermittent wind generation. The PIRP allows intermittent resources (i.e., wind and other resources with an uncontrollable fuel source) to schedule energy in the forward market without incurring imbalance charges when the delivered energy differs from the scheduled amount. A key ingredient to implement the new Intermittent Resource scheduling methodology is to develop near real time, state-of-the-art wind generation forecasts. Scheduling Coordinators representing “Participating Intermittent Resources” will use these forecasts as the “preferred” Energy Schedules submitted to CA ISO. Wind generators that submit Preferred Schedules based upon these forecasts will escape the daily uninstructed deviation charges and instead be assessed deviation charges based upon monthly net deviations between metered and scheduled energy. These monthly net deviations are expected to approach zero as the modeled forecasts produced by the Consultant provide unbiased results. In September of 2001, the CA ISO Board of Governors approved a consensus proposal that would develop new rules for scheduling Intermittent Resources. The CA ISO, working to encourage the development of wind generation as directed by the California Intermittent Resources Group and the CA ISO Board of Governors, has developed a scheduling methodology that minimizes the potential volatility of deviation charges on wind energy suppliers in a way that avoids both the creation of subsidies and the shifting of cost. In early 2002, CA ISO filed a revision to Amendment No. 42 of the CA ISO Tariff that seeks Federal Energy Regulatory Commission (FERC) approval for the implementation of these new rules. PIRP is officially operational at this moment.

To successfully integrate intermittent resources (i.e. wind, solar) into reliable operation of the power grid, CA ISO, Control Area Operators and Scheduling Coordinators need new “look-ahead” tools and strategies. CA ISO must dynamically schedule its Control Area generation and interchanges to respond to changes in the wind generation and avoid creating imbalances between electricity demand and supply. To meet these scheduling and dispatching needs, a near real-time wind energy forecasting tool is essential. At the same time wind plant operators will benefit by having hour- and day -ahead capability allowing them to competitively bid in the energy markets and to plan for maintenance. Accurate, economical and timely forecasting capability is essential for CA ISO’s new market restructuring initiatives (PIRP and new market design MD02).

**Estimated Forecasting Benefits to the Power Grid and CA ISO:**

The success of PIRP, and the future of connecting intermittent resources, relies entirely on the accuracy and reliability of state-of-the-art forecasts to predict wind generation resources. Based on initial cost benefit studies, performed by CA ISO during PIRP inception and planning, 320MW of new wind generation capacity on the grid in 2004 would cost the wind industry an estimated \$4.5M in imbalance and uninstructed penalties (pre-PIRP). With increasing penetration of intermittent wind generation resources, the penalties climb to over \$14M with 1000MWs of new generation. By incorporating a wind forecasting capability with a maximum error of 12% (monthly deviation from scheduled in megawatt hours (MWh)) and 0.6% monthly bias (PIRP), uninstructed penalties costs would drop to approximately \$850,000 for 320MW and \$2.6M for 1000MW, representing a savings of 81% over pre-PIRP figures. These savings alone justify the forecasting service (Table 1).

Table 1. Estimated Forecasting Costs and Benefits

Year	Cost Without PIRP (\$)	Cost With PIRP (\$)	Cost of Forecast (\$)	Benefit (\$)
2004	4,557,773	843,955	84,396	3,713,818
2005	7,121,520	1,318,680	131,868	5,802,840
2006	14,243,040	2,637,360	263,736	11,605,680

From an economic standpoint, any ability to obtain accurate forecasts would benefit the system and the industry. From the grid reliability and operating standpoint, wind forecasting (near-term, within the operating hour) would help ISO operations better anticipate and minimize the imbalance energy requirements.

The goal under the CEC funded forecasting program is to continue to develop, refine and demonstrate the implementation of the “best” forecasting capability. Targets are to further reduce forecasting error to below 10% and to reduce the bias to 0.3%. Based on prior forecasting project experience, the Commission supports industry development of a hybridized (statistical & meteorological) forecasting capability to meet the demands of the expanding market.

**Goals of the Work Authorization:**

The goal of this Work Authorization is to increase the practical limit by 20% on the nameplate rating of wind generation that can be installed in California, due to high-wind penetration impacts on the grid.

**This project supports the PIER Program objectives of:**

- Improving the Energy Cost/Value of California’s Electricity by allowing use of renewable resources to supply the grid in a cost-effective manner.

- Improving the Environment by allowing increased use of renewable energy resources.

**Proposed Outcomes:**

1. Support CA ISO in the development of a viable competitive market for intermittent wind resources and pave the way for increasing market penetration of renewable resources.
2. Leverage the experiences gained under the prior forecasting effort to improve forecasting accuracy and provide capabilities to meet both short-term and longer-term forecast timeframes.
3. Develop a hybridized (statistical & meteorological) wind energy forecasting capability.

**Project Status:**

The project is slightly behind schedule due to delays in subcontracting and data acquisition. Current work is directed toward reducing errors in long-term forecasting and in developing an algorithm for short-term forecasts to support CA ISO's Participating Intermittent Resources Program.

## **REN Active Projects from Previous Years**

## Commonwealth 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, Inc.

**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

**Status:** Active

### Program Description:

The Commonwealth program consists of one Program Administration project and six linked renewable energy projects including:

1. Program Planning and Analysis.
2. Enhanced Landfill Gas Production Using Bioreactors.
3. Enhanced Energy Recovery through Optimization Of Anaerobic Digestion and Microturbines.
4. Dairy Waste to Energy.
5. Building Integrated PV Testing and Evaluation.
6. Building Integrated PV on Public Facilities.

The six linked projects 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.
- Demonstrate the potential for taking advantage of cost economies by installing relatively large PV systems under common ownership arrangements.

### 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.
- 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:**

1. 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.
2. Design, build, and operate two pilot projects to advance the state of knowledge for using bioreactors at landfills.
  - Increase landfill gas production.
  - Improve the characteristics of the waste to accelerate reclamation.
  - Develop and implement a strategy for developing bioreactors while meeting applicable groundwater and other environmental standards.
  - Establish the economic and environmental benefits of the use of landfill bioreactors.
3. Demonstrate enhanced energy recovery and cost effective systems to improve and optimize digester gas production through ultrasound processes and develop cost-effective biogas cleanup systems. At least three biogas cleanup systems will be developed and the installed and the operating cost for each of these systems will be determined for the full project lifecycle.
4. Develop advanced and cost effective anaerobic digestion technologies that can be used to maximize energy recovery from animal waste. One (or more) operating pilot plant(s) will be built using the technologies developed in the project to convert dairy waste to biogas electricity ranging in size from 60 kilowatt (kW) to 5 megawatts (MW).
5. Address the gap between future third-party certified photovoltaic (PV) component and system performance results and currently available information from manufacturers. Three small (2 kW each) and three large (20 kW each) PV systems will be installed using the best technologies developed. Live system performance data will be provided to the public through the website established in the program. In addition, a Consumer Reports-type rating manual will be completed that can be used by manufactures, system integrators and customers to guide the selection and design of building-integrated photovoltaic systems.
6. Demonstrate the potential for taking advantage of affordability improvements and value added applications by demonstrating a number of new and repeatable project development approaches in public facilities with relatively large building integrated PV systems. A set of specific photovoltaic facilities expected to range in size from 10 kW up to 150 kW will be completed each addressing an infrastructure or commercialization barrier. Thus achieving the PIER objective of demonstrating the potential for taking advantage of cost economies by installing relatively large PV systems with at least one under common ownership arrangements.

**Program Status:**

- The Program Planning and Analysis project is moving forward within its original approved scope of work. The project is near completion. The Prioritization Final Report and Draft Project Final Report are currently under reviewing.
- Work has ceased since July 2004 on the Enhanced Landfill Gas Production Using Bioreactors project due to several issues on the design and permit with the bioreactor at Mid-Valley.
- Two ultra-sound systems including Institute of Water and Environment (IWE) Tech and Sonico have been installed at Riverside's Wastewater Treatment Plant in California. The project team is currently working on collecting performance data that will be completed by September 2005. By applying ultra-sound technology in sewage organic wastes, the biogas electricity generation is expected to increase by 30% with an incremental pay back period of 2 years. Two biogas clean-up systems have been designed.

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- Activities on the Dairy Waste to Energy project are limited to the environmental testing level due to the concerns with the change in the scope of work. The Contractor has not been able to follow the original scope of work. The new proposed scope of work has been questioned and not yet approved.
- The Building Integrated PV Testing and Evaluation project has been moved forward well toward its original scope of work. The project team is currently continuing to monitor the output and ambient conditions from each of the three small (2 kW) systems and three large (20 kW) PV systems. Live system performance data are provided to the public through the website established for the program:  
⇒ [www.pierminigrid.org](http://www.pierminigrid.org)
- Activities on the Building Integrated PV on Public Facilities project are limited at the site selection level. The Contractor has not been able to follow the original scope of work. The proposed scope of work and budget have been questioned and not approved.

**Continued: Commonwealth Biogas/PV Micro-Grid Renewable Resource Program**

**Commonwealth Project 0.0 - Program Administration**

**Contract Project Amount:** \$889,771

**Contract Project Manager:** Patrick Lilly (360) 906-0616

**Commission Project Manager:** Zhiqin Zhang, (916) 654-4063

**Project Description:**

The project will coordinate R&D efforts between projects. The coordination includes overseeing assessment studies, tracking R&D progress and deliverables, ensuring the quality of RD&D results, identifying and facilitating program linkages between projects, implementing mechanisms to revisit the program’s research direction and focus as research results are achieved, ensuring connection with the market and linkage to utility deployment programs, and establishing systems for reliable internal and external communications throughout the contract period.

**This project supports the PIER Program objective of:**

- Improving energy cost/value by coordinating R&D efforts between projects in the Commonwealth Biogas/PV Micro-Grid Renewable Resource Program.

**Proposed Outcomes:**

1. Manage the program to achieve the specified technical and economic performance goals.
2. Ensure that research results meet guidelines for quality within budget and schedule.

**Project Status:**

The project director and team members have been working well with the Energy Commission in providing strategic guidance to the Program Management Team; reviewing current and future deliverables to evaluate functionality of the deliverables; providing specific suggestions/recommendations for needed adjustments, refinements, or enhancement of the deliverables; and provide recommendations regarding information dissemination, market pathways or commercialization strategies relevant to the research products.

**Continued: Commonwealth Biogas/PV Micro-Grid Renewable Resource Program**

**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.
- 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:**

1. Develop an analytical tool to match renewables mixes to the forecasted pattern of local area demand.
2. Demonstrate how generation facilities can be made more cost effective and the energy they produce more affordable.
3. 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 Program Planning project is moving forward within its original approved scope of work. The project is near to the completion. The Prioritization Final Report and Draft Project Final Report are currently under review.

**Continued: Commonwealth Biogas/PV Micro-Grid Renewable Resource Program**

**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.
- 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 (CH<sub>4</sub>) production, estimation of direct reductions in CH<sub>4</sub> emissions, 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 objectives 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.
- Improving the environment, public health, and safety by quantifying greenhouse gas and pollution reduction benefits.

**Proposed Outcomes:**

1. Develop a conceptual design for two types of landfill bioreactors.
2. Develop two types of landfill bioreactors.
3. Develop environmental documentation to satisfy regulators.
4. Incremental gas production from both of these pilot reactors will be in the range of 1 to 5 megawatts (MW).

**Project Status:**

Work has been on hold since July 2004 on the Enhanced Landfill Gas Production Using Bioreactors project due to several issues on the design and permit with the bioreactor at Mid-Valley.

**Continued: Commonwealth Biogas/PV Micro-Grid Renewable Resource Program**

**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 objectives of:**

- Improving energy cost/value of California electricity by the development of piloting for thermal hydrolysis and ultrasound treatment systems to increase biogas production.
- Improving the environment, public health, and safety by developing and testing gas cleaning systems well suited for microturbines it will be possible to reduce installation, operation, and maintenance costs and achieve emissions reductions.

**Proposed Outcomes:**

1. Employ technologies to improve gas production and energy generation and the overall efficiency of their facility.
2. Increase and optimize digester gas production through thermal hydrolysis and ultrasound processes.
3. Develop and optimize cost effective gas cleanup systems.
4. Evaluate and quantify environmental benefits that result from using micro-turbines at sewage treatment plants.
5. Evaluate performance and cost during operation so sewage treatment plants have greater certainty on the cost and reliability of using micro-turbines.

**Project Status:**

Two ultra-sound systems including IWe Tech and Sonico have been installed at the Riverside's Wastewater Treatment Plant in California. The project team is currently working on collecting performance data that is scheduled for completion by September 2005. By applying ultra-sound technology in organic sewage wastes, the biogas electricity generation is expected to increase by 30% with an incremental pay back period of 2 years. Two biogas clean-up systems have been designed.

**Continued: Commonwealth Biogas/PV Micro-Grid Renewable Resource Program**

**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. Technologies that will be applied to improve the 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 the 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:**

1. Demonstrate key technical components of an integrated waste management/energy recovery system.
2. Develop technologies that can be used to maximize energy recovery from animal waste.
3. Develop and evaluate different pilot projects that will include facilities at existing treatment plants, individual dairies, and at clusters of dairies.
4. Evaluate and test the effectiveness of low and high technologies developed in North America and Europe for the collection of, processing of, and energy recovery from animal waste.

**Project Status:**

Early in 2004, the Contractor notified the Commission that the expected match funding would no longer be available for this project and requested time to arrange for new match funding or to change the scope of work to reflect the available funds. Work is currently limited to those tasks that meet the original scope of work.

**Continued: Commonwealth Biogas/PV Micro-Grid Renewable Resource Program**

**Commonwealth Project 3.2 - Building Integrated PV Evaluation**

**Contract Project Amount:** \$870,099

**Match Funding:** \$602,500

**Contract Project Manager:** Chuck Whitaker (925) 552-1330

**Commission Project Manager:** Elaine Sison-Lebrilla (916) 653-0363,  
Zhiqin Zhang (916) 654-4063

**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 the 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 California’s electricity reliability, quality, and sufficiency and improving the quality of systems installed through directed training.

**Proposed Outcomes:**

1. Address the gap between future third-party certified photovoltaic (PV) component and system performance results, and currently available information from manufacturers.
2. Provide an independent comparative evaluation of PV systems critical to Project 3.3 and to the Commission Buydown Program.
3. Provide decision-making information on those PV systems.

**Project Status:**

This project has made good progress. The Building Integrated PV Testing and Evaluation project has been moving forward well toward its original scope of work. The project team is monitoring the output and ambient conditions from each of three small (2 kilowatt (kW)) and three large (20 kW) PV systems. Live system performance data are available (<http://pierminigrid.showdata.org/monitor/>) to the public through the website established for the program (<http://pierminigrid.showdata.org/>).

**Continued: Commonwealth Biogas/PV Micro-Grid Renewable Resource Program**

**Commonwealth Project 3.3 - Building Integrated PV Generation**

**Contract Project Amount:** \$827,686

**Match Funding:** \$2,350,000

**Contract Project Manager:** Vincent I. Schwent (916) 837-6380

**Commission Project Manager:** Elaine Sison-Lebrilla (916) 653-0363,  
Zhiqin Zhang (916) 654-4063

**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 Building Integrated Photovoltaic (BIPV) systems and innovative project development models.
- Facilitating relationships between supply- and demand-side stakeholders.
- 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:**

1. Establish credibility of the implementation model.
2. Improve the affordability of higher cost systems.
3. Reduce installed PV costs per peak watt and per life cycle kilowatt hour (kWh).
4. Find ways to add outside inherent value to the PV system installation over its life.

**Project Status:**

Activities on the Building Integrated PV and Public Facilities project are limited at the site selection level while the Contractor seeks additional match funding.

## Biogas-fueled Low Emission HCCI Generator

**Contract #:** PIR-02-003

**Contractor:** Makel Engineering Inc./Darby B. Makel

**Subcontractors:** University of California, Berkeley

**Contract Amount:** \$457,042

**Match Amount:** \$149,995

**Contractor Project Manager:** Darby Makel (530) 895-2771

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

**Status:** Active

### Project Description:

The purpose of this project is to demonstrate the applicability of low-emission homogeneous charge compression ignition (HCCI) engine technology for landfill gas (LFG) fueled power generation at the Butte County Neal Road Solid Waste Management Facility.

The biogas-fueled low-emission HCCI engine-generator project provides a low-risk path to high-efficiency, low-emissions and low-cost power generation relative to any other technology. This proposed project would install a 100kW system at the Butte County Neal Road landfill facility. HCCI technology is uniquely suited to address the key challenges related to landfill gas power generation such as low energy content, variable ignition characteristics (octane value), and contaminants. These issues present less of a problem to HCCI engines than to conventional engines, gas turbines and fuel cells. If successfully developed, the technical advancements of this research would include:

- Optimizing the power output and emissions of the HCCI lean-burn engine: Demonstrate the efficiency of the engine while maintaining ultra low nitrogen oxides (NO<sub>x</sub>) emissions and acceptable power density.
- Tuning the Control System to perform on the variable energy density of landfill gas: Demonstrate the stability of the engine considering that engine control is difficult because there is no spark plug (good), no fuel injector (good), and thus, no direct control of the ignition timing (bad).
- Leveraging the Fuel Flexibility of the HCCI Engines to operate on landfill gas: Demonstrate the durability of the engine running on waste gas with potential contaminants and corrosives.

### This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing a low-cost high-efficiency distributed power generation engine that runs on LFG.
- Improving the environmental and public health costs/risk of California's electricity by efficiently using LFG to generate electricity (removing this potent greenhouse gas from the environment) while limiting the engines emissions to very low levels.

### Proposed Outcomes:

1. Demonstrate NO<sub>x</sub> emission of 0.005 pounds per million British thermal units (lb/MM Btu) and how HCCI engine technology contributes to improving both the environmental and human health conditions through utilizing LFG as a feedstock thus removing it from the atmosphere where it is a potent greenhouse gas.
2. Demonstrate the real world effectiveness of HCCI engine technology utilizing LFG at 35% efficiency (both emissions and power), stability (consistent engine performance over time, less than 10% variation on efficiencies) and durability (>10,000 hours between overhauls).

3. Demonstrate the market ready potential of HCCI engine technology as a low-cost and high-efficiency source of distributed electric power generation.
4. Reduce the cost of electricity generation by 50% to <0.05 \$/kilowatt hours (kWh).
5. Reduce of the cost of system installation to <750 \$/kilowatt (kW).

**Project Status:**

- Design package for the landfill gas fueled HCCI engine system was completed and HCCI engine system was built.
- Bench test plan was completed.
- Work is progressing for the bench scale testing for natural gas and simulated landfill gas.
- The Contractor is within schedule and budget.

## California Biomass Collaborative

**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

**Status:** Active

### Project Description:

The purpose this project is to create a forum to address ways to further the beneficial development of biomass energy in California. As the only California-focused effort of this kind, the Collaborative will serve as a unique forum for coordinating biomass energy development in the State among key stakeholders. The Collaborative will also provide the Commission with access to biomass energy expertise that will help in achieving objective and timely evaluation of biomass energy policies, and evaluation and implementation of proposed biomass energy technology innovations.

The mission of the Collaborative is to enhance the development of sustainable and beneficial biomass energy systems for the State of California. To fulfill this mission, the Collaborative plans to administer a comprehensive statewide program addressing research and innovation technology development, demonstration, and deployment and biomass energy education and training. The Collaborative plans to accomplish this mission through the close cooperation of representatives from California's biomass energy and products industries, affected federal and state agencies, the environmental community, and from research and academic institutions involved in biomass energy developments.

### This project supports the PIER objectives of:

- Improving the environment, public health and safety of California's electricity by advancing the State's renewable biomass energy industry.
- Providing more energy choices for California ratepayers by maximizing the market connectivity of biomass technologies developed through the PIER program.

### Proposed Outcomes:

1. Organization and management of a diverse collaborative advisory group (the Collaborative) to provide immediate expertise in areas pertaining to biomass energy including technologies, resources, design, siting, construction, operation, maintenance, generation, and modeling.
2. Organization of an executive board to administer the overall function of the Collaborative.
3. Enlistment of staff to carry out the day-to-day and project-oriented activities of the Collaborative.
4. Establishment of a physical focal point for biomass energy related questions/activities in the State.
5. Development of 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.

6. Support statewide biomass-related geographic information systems (GIS) modeling efforts and enhance state level biomass inventory data.
7. Creation of a California Biomass Facilities Reporting System to provide up-to-date information on biomass power facilities and facility performance.
8. Development of a Collaborative web site for disseminating and improving public access to biomass information, data, white papers, and Consortium activity reports.

**Project Status:**

- First year project is 95% complete, term extension is being arranged.
- The Collaborative has been fully organized and attracted membership of about 400 with 22 Executive Board members.
- The Collaborative web site was developed and has been operational for disseminating and improving public access to biomass information, data and Collaborative activity reports. Newsletters were also initiated and distributed to members and other interested parties. They are available at:  
⇒ <http://biomass.ucdavis.edu/>
- The First Annual Forum was completed and the Second Annual Forum has been planned on March 1, 2005.
- The Biomass Resource Assessment (except forest biomass) has been completed. The biomass inventory data has supported the biomass-related GIS modeling efforts through the Strategic Value Analysis for Renewables.
- The white paper, entitled: “Biomass in California: Challenges, Opportunities, and Potentials for Sustainable Management and Development” was drafted.
- Developed web accessible economic models for biomass energy conversion technologies.
- Reports on a power generation assessment and a biomass facilities reporting system are being completed.

## Community Choice Aggregation Pilot Project

**Contract #:** 500-03-004

**Contractor:** Local Government Commission (LGC)

**Subcontractors:** Navigant Consulting, Inc.

**Contract Amount:** \$694,000

**Contractor Project Manager:** Patrick Stoner (916) 448-1198

**Commission Contract Manager:** Hassan Mohammed (916) 651-9855

**Status:** Active

### Project Description:

The purpose of this contract is to develop a template that local governments can use in evaluating the feasibility of implementing Community Choice Aggregation (CCA) within the context of the California Renewables Portfolio Standard (RPS). The template will be developed based on assessments conducted with a minimum of three pilot communities. The template will address the technical and economic aspects of incorporating renewables under a community aggregation vehicle, and lessons learned by pilot communities. In addition to the developed template, a report will be prepared on the procedures established by the California Public Utilities Commission (CPUC) in implementing CCA. Both the template and the report on the CPUC's implementation process will be disseminated to interested communities through workshops and publications.

Passage of recent legislation has created significant changes in California's electricity markets. AB 117 (2001-02) (Migden) and SB 1078 (2001-02) (Sher) provides local governments with the ability to aggregate electricity loads within their communities and act on behalf of those customers in selling and purchasing electricity, transmission and other services. The RPS requires retail sellers of electricity, including electric service providers, electrical corporations and community choice aggregators to increase their purchase of electricity from renewable sources to twenty percent by 2017. Due to the rich supplies of indigenous renewable resources in California and adjacent states, retail electricity sellers will look increasingly at regional supplies of renewables to help achieve the RPS goals. Similarly, some communities in California have interest in developing a renewable portfolio mix that significantly exceeds the State's RPS twenty-percent goal.

### This project supports the PIER Program objective of:

- Expanding the use of renewable energy technologies in California's electricity mix by developing a template that local governments can use in evaluating the feasibility of implementing Community Choice Aggregation (CCA) within the context of the California Renewables Portfolio Standard (RPS).

### Proposed Outcomes:

1. Develop a template of analytical and cost models that can be used by a variety of local governments in California in assessing ways to implement CCA in such a fashion to significantly exceed the State's RPS goals.
2. Prepare a document that clarifies the costs, credits, rules and protocols being established by the CPUC for implementing CCA.
3. Develop a CCA pre-feasibility study model.
4. Complete detailed CCA feasibility analyses for up to three communities or groups of communities that demonstrate the use of the template and ways in which these communities can significantly exceed the State's twenty-percent RPS goal.
5. Develop and provide a guidebook, fact sheet, and workshops for local government elected leaders and staff that share the lessons learned with the pilot communities.

**Project Status:**

The Project is active. The CPUC has added an additional pre-hearing conference and workshops for the proceedings, and will issue two draft and final decisions instead of one as originally expected. Therefore, the project is expected to be extended for one more year and be completed by the end of December, 2006.

In the past year, the Local Government Commission / Navigant Consulting Inc. had completed the following tasks:

**Task 2: CPUC CCA Process**

Two draft and two final CPUC Process Progress Reports were completed, including summary of Phase 1 in the proceeding. The CPUC Process Report will be completed when the CPUC makes its decision in Phase 2.

**Task 3: Pilot Communities' Selection**

The project required participation of 3 communities, one in each Investor Own Utility (IOU) service territory. The communities in the project are:

PG&E Territory

Berkeley, Emeryville, Marin County & its cities, Oakland, Pleasanton, Richmond and Vallejo.

SCE Territory

Beverly Hills, LA County, Torrance and West Hollywood.

SDG&E Territory

San Diego County and San Marcos.

**Task 4: Initiate Pilot Communities' Participation**

Initial participant meetings have been held in all three IOU territories. The first renewable workshop in each territory has been held. The second workshop will occur as the communities prepare to file their implementation plans.

**Task 5: CCA Base Case Feasibility Studies**

Base Case Feasibility Studies have been completed for:

Berkeley, Beverly Hills, Emeryville, LA County, Marin County & its cities, Oakland, Pleasanton, Richmond, Vallejo and West Hollywood.

Base Case Feasibility Studies are being refigured after the CPUC Phase 1 decision. The more recent participants (San Diego County, San Marcos and Torrance) will use the Phase 1 decision numbers instead of the assumptions used in the earlier studies.

**Task 6: CCA Base Case Evaluation**

Assumptions for key variables have been completed and draft recommendations to pilot communities have been made for communities in two of the three IOU territories.

**Task 7: CCA Implementation Plans**

Work has begun on the draft CCA implementation plan template, but no deliverable has been completed.

**Task 8: Monitor CCA Implementation Plans a CPUC**

This work will follow participants' filing of implementation plans.

**Task 10: Technology Transfer Activities**

LGC attended and presented at the Southwest Renewable Energy Conference in Flagstaff in August. Work was initiated on an Integrated Energy Policy Report (IEPR) workshop focusing on the potential for CCA and renewable energy in California.

## Co-Production of Silica from Geothermal Fluids

**Contract #:** PIR-00J-003

**Contractor:** Lawrence Livermore National Laboratory

**Subcontractors:** Mammoth Pacific LP

**Contract Amount:** \$669,683

**Match Amount:** \$167,420

**Contractor Project Manager:** William L. Boucier (925) 423-3745

**Commission Contract Manager:** Pablo Gutierrez (916) 654-4663

**Status:** Active

### Project Description:

The purpose of this project was to develop a commercial technology to efficiently extract silica from geothermal fluids and generate a new net revenue stream through the sale of the mineral by-product. Additional benefits included providing a potential source of evaporative cooling water that could result in increased megawatt generation, and the reduction of operating and maintenance costs.

### This project supports the PIER Program objective of:

- Improving energy cost/value of California's electricity by selling 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:

1. Develop a commercial technology to efficiently extract silica from geothermal fluids. Lawrence Livermore National Laboratory's (LLNL) work focused on precipitation and post-processing techniques that resulted in silica of the appropriate purity, particle size, surface area, density, pore size distribution, and degree of agglomeration for specific industrial uses and suitable for use in a number of commercial products.
2. Successfully market silica:
  - Match the physical and chemical properties of silica used in a particular market.
  - Identify markets that are large enough to absorb the volume of geothermal produced silica.
  - Obtain a price for produced silica such that the silica extraction process is economic.

### Project Status:

The project is 95% complete. The final report is under review.

LLNL chose to work at the Mammoth Lakes, CA site operated by Mammoth Pacific L.P. (MPLP) for this project. The geothermal fluid at this site is among the cleanest in terms of other dissolved species, so it is an optimum site for producing high-quality, high-purity silica. MPLP also needs low-silica water to increase their power production in the summer. The low-silica water is cycled through cooling panels to reduce fluid temperatures downstream from the turbines. The low-silica water is produced as a by-product of LLNL's extraction process. MPLP therefore has a dual use for the silica extraction process.

LLNL has shown that they can produce marketable silica by-products, both as a solid precipitate useful in rubber binder applications, and colloidal slurry useful in precision casting and paper applications. The market value of silica that could potentially be produced from the Mammoth

Lakes site is about \$10,000,000/year based on a typical market price of \$0.70/lb for precipitated silica used in rubber manufacture and a silica recovery of 7200 tons per year. For a process that treats and extracts silica from the entire fluid stream, the estimated capital cost for the extraction technology is \$40,000,000 with operating costs of about \$4,000,000 per year. These preliminary estimates suggest a rate of return of about 16% and payout in 7 years.

However, these estimates are highly preliminary. LLNL believe that uncertainty in the economics of silica extraction has been the major impediment to the commercialization of silica co-production. Pilot testing will be required to optimize the design of a silica extraction system and to validate that design by long-term testing. Data from the pilot test can then be used to rigorously determine the economic feasibility of full-scale silica extraction at the Mammoth Lakes site.

## Hydrogen-Assisted Lean Operation for Biogas Reciprocating Engines

**Contract #:** PIR-02-001

**Contractor:** TIAX LLC

**Contract Amount:** \$497,811

**Match Amount:** \$133,000

**Contractor Project Manager:** Larry R. Waterland (408) 517-1572

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

**Status:** Active

### Project Description:

The purpose of this project is to develop and demonstrate a nitrogen oxides (NO<sub>x</sub>) control technology that can be applied to biogas-fueled reciprocating internal combustion engines to achieve greater than 90 percent NO<sub>x</sub> reductions from the state-of-the-art for lean-burn biogas-fueled engines that is currently designated best available control technology (BACT). The technology relies on the addition of hydrogen-containing biogas reformat to the engine's biogas fuel, which in turn allows the lean limit of the combustion process to be extended to much higher air/fuel ratios.

By extending the lean combustion limit and operating the engine under leaner conditions, peak cylinder flame temperatures are decreased and extending the lean combustion limit and operating the engine under leaner conditions substantially reduces NO<sub>x</sub> emissions. The hydrogen containing reformat will be produced by reforming a portion of the biogas fuel in an autothermal reformer onsite. The project will develop this technology, fabricate a reformer, install the reformer and a 75 kilowatt (kW) engine-driven co-generation unit at the Marysville landfill of Norcal Waste Systems, and demonstrate the performance of the technology operating on biogas fuel/feed at the host site.

### This project supports 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.

### Proposed Outcomes:

1. Successful development and demonstration of a landfill gas autothermal reformer with a 70 percent conversion efficiency. Conversion efficiency is defined as (hydrogen gas (H<sub>2</sub>) + carbon monoxide (CO)) produced/methane (CH<sub>4</sub>) fed.
2. Demonstration of an engine heat rate of 10,000 British thermal unit (Btu)/ kilowatt hours (kWh) and combined heat and power (CHP) heat rate of 6,017 Btu/kWh.
3. Use the landfill gas reformat to reduce internal combustion (IC) engine NO<sub>x</sub> emissions to 0.032 grams per brake horsepower-hour (g/bhp-hr) (0.10 lb/MWh) without the CHP credit. With the CHP credit, NO<sub>x</sub> emissions will be 0.02 g/bhp-hr (0.06 lb/MWh).
4. Make a best effort to achieve the central station power plant Best Available Control Technology NO<sub>x</sub> level of 0.02 g/bhp-hr (0.06 lb/MWh) without the CHP credit.
5. At production volumes of approximately 100 units per year, a reformer capital cost of \$300/kW (where kW is H<sub>2</sub> + CO thermal equivalent on a lower heating value (LHV) basis).
6. Installed capital cost of commercial system less than 1000 \$/kW.
7. Simple payback period less than 3 years.

**Project Status:**

- This project is behind schedule due to delay in obtaining the needed permits and permission to install the engine/generator set stand for the project at either the Marysville landfill host site or the TIAX engine laboratory facility in Cambridge.
- Despite of the delays, this project is within budget.
- Completed a number of engine modifications needed to allow planned scoping tests to take place.
- The engine was successfully started and run for several hours using bottled natural gas.
- Contractor is expected to achieve the desired outcomes and be on schedule in 2005.

## Landfill Gas Fired 250 kW Microturbine

**Contract #:** PIR-02-002

**Contractor:** Stearns, Conrad and Schmidt Consulting Engineers, Inc.

**Subcontractors:** Ingersoll-Rand

**Contract Amount:** \$450,000

**Match Amount:** \$499,047

**Contractor Project Manager:** Jeffrey L. Pierce (562) 426-9544

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Active

### Project Description:

The purpose of this project is to install and demonstrate a 250 kilowatt (kW) beta microturbine on landfill gas. At the present time, the largest microturbine that has been proven in landfill gas service is a 70kW microturbine.

The introduction of a larger microturbine to the landfill gas (LFG) market would: 1) reduce total installed cost of the technology on a \$/kW basis, and 2) enable the technology to be used for larger projects and, as a consequence, increase microturbine technology's distributed generation market share in the capacity range (500 kW to 2,000 kW) – a range which is currently ceded to reciprocating engines. Ingersoll-Rand will supply the 250 kW microturbine. Ingersoll-Rand is currently in the microturbine business and is currently manufacturing and selling a 70 kW microturbine. Ingersoll-Rand has marketing, distribution and service network and a microturbine manufacturing capability, which will support immediate commercial deployment of a successfully demonstrated beta unit.

### This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing a low-cost high-efficiency distributed power generation engine that runs on LFG.
- Improving the environmental and public health costs/risk of California's electricity by efficiently using LFG to generate electricity (removing this potent greenhouse gas from the environment) while limiting the engines emissions to very low levels.

### Proposed Outcomes:

1. Introduce a market-ready-250 kW microturbine which is able to be fired on landfill gas.
2. Increase the number of landfill gas-fired microturbine projects in the 200 kW to 500 kW size range.
3. Position microturbines to compete with landfill gas-fired reciprocating engines in the 750 kW to 1,500 kW size range, reducing NO<sub>x</sub> emissions by 800 tons per year on a statewide basis.
4. Add as much as 30 MW of otherwise unrealized landfill gas-fired microturbine capacity in California within the next five years (versus the currently installed and under construction 2.5 MW).
5. Reduce capital cost of landfill gas-fired microturbine installations by 20 percent to 25 percent.
6. Reduction of cost of power from landfill gas-fired microturbine projects by 20 percent to 25 percent.

7. Attainment of project’s stretch goals as indicated below:

Affordability (COE)	\$0.048/kWh
Energy Recovery System Capital Cost	\$1,600/kW
Prime Mover Capital	\$800/kW
Prime Mover Lifetime	10,000 hours +
Capacity Factor	93%

**Project status:**

Project kickoff meeting was held on August 6, 2003 in Sacramento. The following is the description of the progress on this project:

1. A kick off meeting was held on August 6, 2002 to review scope of work and administrative items.
2. The microturbine will be located in the Burbank Landfill. The City of Burbank has approved a general arrangement plan for the location of the microturbine.
3. Stearns, Conrad and Schmidt has submitted a permit application with the South Coast Air Quality Management District (SCAQMD) for their review. Documentation has also been filed for the California Environmental Quality Air (CEQA) utility interconnection, and for a building permit.
4. The Contractor has submitted the final Design Modification Report and test plan. Ingersoll-Rand has fabricated the modified 250kW microturbine.
5. The landfill gas compression/treatment skid is being fabricated and will be delivered to the site by the end of January 2005.
6. Installation of the microturbine is currently taking place at the Burbank Landfill.

## Ocean Wave Energy Resource Assessment for California

**Contract #:** 500-01-018

**Contractor:** California State University, San Diego

**Subcontractors:** Neptune Sciences

**Contract Amount:** \$120,000

**Contractor Project Manager:** Asfaw Beyene (619) 594-6207

**Commission Contract Manager:** Mike Kane (916) 654-7119

**Status:** Active

### Project Description:

The purpose of this project is to conduct an assessment of ocean wave energy resources off California's coast and determine the technical, economic and environmental feasibility of using ocean wave energy systems to provide electricity to the State's electricity system. In addition, the project will identify potential sites best suited for ocean wave energy development along the coastline. An earlier evaluation by Pacific Gas and Electric in 1991 estimated an average of 30 to 40 kilowatts per linear meter (kW/m) of available energy in ocean waves off California's northern coast. Harvesting 20% of the northern California's potential wave energy could provide upwards of 4000 MWs (megawatts) of electricity.

Under this project, 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 wave energy conversion systems (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 will be identified associated with deploying WECs off California's coast.
4. Assess the amount of electricity that can be developed from ocean wave energy resources off California's coast, given the technical, economic and environmental considerations. 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 can generate electricity 24 hours a day.
- 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:**

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

**Project Status:**

The draft final report was received and was reviewed. The Energy Commission is requesting that economic and permitting portions of the final report be strengthened with additional input from the WEC industry and the California Coastal Commission. The work authorization is to be extended (no-cost) through September, 2005.

## Photovoltaic Power Generation with Direct Current Applications

**Contract #:** 500-02-014 **Work Authorization #:** E2I-WA-106

**Contractor:** Electricity Innovation Institute

**Project Amount:** \$24,800

**Contractor Project Manager:** Terry Peterson (650) 855-2594

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

**Status:** Active

### Project Description:

Traditional use of photovoltaic (PV) power in grid-connected applications involves the use of solid-state power-electronic devices called inverters to convert the PV modules' DC output to AC power. These inverters unavoidably add to system cost and lower system efficiency. Furthermore, to date, they have proven to be the least reliable and durable component of grid-connected PV installations.

This project is intended to significantly advance the economics of photovoltaic (PV) energy by investigating approaches for applying PV in non-traditional DC-power applications without inverters. Unlike conventional DC uses for PV energy, such as off-grid telecommunication sites, navigation beacons, and billboard lighting, this project will develop the hardware and demonstrate the powering of loads at grid-connected buildings in cases where the PV can provide supplemental DC power without interference to the AC distribution system or load. Potential examples include adjustable-speed motor drives, building lighting systems, appliances with switch-mode power supplies, heating systems, and uninterruptible power supplies. This project includes a feasibility study, hardware development and a completed demonstration with performance results.

The goal of this Work Authorization is to significantly advance the economics of PV energy by investigating approaches for applying PV in non-traditional DC-power applications.

### This project supports the PIER Program objective of:

- Improving the environment and public health costs/risk of California's electricity by enabling more cost-effective—and therefore, wider—use of PV electricity in grid-connected applications. To the extent that DC-PV applications displace more conventional grid-connected PV deployments, this Work Authorization also meets the PIER Goal of Improving the Energy Cost/Value of California's Electricity, because it will improve the economics of PV utilization.

### Proposed Outcomes:

1. Demonstrate the feasibility of at least one novel DC-PV application.
2. Quantify its economic advantages compared to traditional AC-connected configurations.

### Project Status:

This project is ongoing. Energy Commission staff are currently reviewing project deliverables.

## Powerwheel Demonstration

**Contract #:** 500-97-037

**Contractor:** Powerwheel Associates

**Subcontractors:** Electrical Maintenance Consultants : Granger Engineering Services : N. J. Mccutchen, Inc. : ERC, Inc. : California State University : California Polytechnic State University, 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:** Mike Kane (916) 654-7119

**Status:** Active

### 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 kilowatt (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.
- 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:

1. Prove the full-scale technical, economic, and environmental suitability of Powerwheel technology for conversion into electricity of the presently wasted renewable energy available in very low-head waterfalls.

### 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. Repairs were made and the waterwheel was reinstalled, but the machine soon experienced additional mechanical difficulties that precluded field testing. Final changes are being made to the final report and the project will be closed out in early 2005.

## Renewable Energy Technology Research and Development Program

**Contract #:** 500-01-042

**Contractor:** Hetch Hetchy Water and Power, San Francisco

**Subcontractors:** CRS : Electranix Corporation : Distributed Generation Systems : GeothermEx, Inc. : E3 : McNeil Technologies : Solargenix : Stirling

**Contract Amount:** \$5,854,585

**Match Amount:** \$1,429,182

**Contractor Project Manager:** Fred Schwartz (415) 554-2425

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

**Status:** Active

### Program 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. Center for Resource Solutions (CRS) is the key subcontractor and program administrator of this programmatic project. Initiated in August 2002, the Program is focused on accelerating the integration of renewable energy into San Francisco municipal energy operations and across California's public power sector, while providing a broad array of R&D benefits applicable across the entire California electricity sector.

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.
- 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 High-Voltage Direct-Current (HVDC) Intertie.

Project 1.2 New Wind Site ID and Qualification.

Project 1.3 New Geothermal Resource Assessments.

### 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 Power Plant.
- 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.
- 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:**

This programmatic project is six to seven months behind schedule and within budget.

- Year two annual report was completed. It highlights the issues and accomplishments of each project.
- In the second year of this programmatic project, several administrative tasks and one technical task were determined to be redundant with other project tasks. At the same time, the management team identified several new technical tasks that complimented the overall Program work scope and were a good fit with the overall goals and objectives.
- Changes were made to the work scope and budgets to Project 0 in the spring of 2004. Under Program Administration (Project 0), the following Deliverables were eliminated:
  - Eliminate Critical Program Reviews 4 and 6.
  - Justification: The Program sufficiently benefits by holding only two more Critical Program Reviews – one in mid 2004 and one in early 2005.
  - Eliminate Year Three Annual Technical Briefing.
  - Justification: The Final Program Meeting occurs in parallel.
  - Eliminate Year Three Year End Report.
  - Justification: The overall Program Final Report occurs in parallel.

A Critical Program Review was held on February 6, 2004. The review was conducted by PIER and Renewables Program staff, SFPUC staff as well as selected members of the Program Research Project Approval Committee (RPAC). The objectives were to conduct a strategic evaluation of overall Program direction in the context of: 1) the results of the project work to date; 2) the relationship of this Program to other PIER Renewables Program activities; and 3) the evolving energy marketplace in California.

Highlights of this Critical Program Review include:

- For bulk power, key development issues for San Francisco and the State as a whole are transmission adequacy, firming wind, and timing of anticipated procurement processes. This Program is producing results that bear on these critical issues.
- RPAC members emphasized the need to communicate Program activities and results relevant to on-going market issues in California and throughout the west. The Commission should stay connected to utility procurements and drive the R&D program to deliver competitive options. RPAC members suggested creating One-page summaries of each project. So, one –page summaries for each project was prepared and being reviewed by Commission staff.
- The PIER and Renewables Programs within the CEC are working together to meet RPS goals. It is critical to integrate the results of this “technology push” initiative with the “market pull” (such as the RPS and the systems benefit charge) happening in California and the western region. There are barriers and opportunities in each policy venue – California Public Utilities Commission (CPUC), Independent System Operator (ISO) and regional organizations.
- A need was also identified to take transmission issues to a multi-agency setting. There will be a statewide transmission plan adopted by CPUC based on utility plans – this Program and other PIER work should feed into that plan. There is an opportunity to link this Program to Center for Energy Efficiency and Renewable Technologies (CEERT) initiatives on renewables and transmission.

**Continued: Renewable Energy Technology Research and Development Program**

**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:** Electranix Corporation

**Project Amount:** \$311,005

**Match Funding:** \$96,076

**Contractor Project Manager:** Fred Schwartz (415) 554-2425,

**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 megawatts (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 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.
- 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:**

1. 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.
2. A corresponding amount of less environmentally friendly energy will be displaced.

3. 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:**

This project with Electranix is ongoing and within budget.

In the past year, Electranix concluded a review of scheduling and control issues on the Pacific DC Intertie, providing valuable insights into the potential and challenges in bringing large additions of renewable energy resources to the California grid. Electranix reported on:

- Pacific Direct Current Intertie (PDCI), transmission system ownership -- Northern segment owned by Bonneville Power Administration (BPA), and Southern segment ownership divided between Southern California Edison (SCE) and four public power agency stakeholders.
- Los Angeles Department of Water and Power (LADWP) and BPA jointly operate and control their respective segments south and north of the NOB.
- PDCI scheduling is coordinated between BPA, LADWP and CAISO.
- An electrical connection to the PDCI north of the Nevada-Oregon border (NOB) requires an interconnection request using BPA’s procedures while a connection south of the NOB would require using LADWP’s procedures. Compelling economic justifications as well as acceptable technical risks are needed to support an interconnection to the PDCI.
- Significant issues:
  - Western Electricity Coordinating Council (WECC) standards need to be followed when planning additions or significant modifications to the western bulk power system. Additionally, planning standards and criteria established by California ISO need to be considered.

- Modifications to PDCI control system will require careful coordination with LADWP and BPA.
- A project to interconnect with the PDCI will require a strongly motivated sponsor with support from both technical and institutional talents.
- There are technical challenges in designing an interconnection at mid-span of the existing DC transmission line. System impact and dispatch factors due to the interconnection of intermittent energy resources must be analyzed.

Other Issues:

Understanding how near-term RPS needs can be met with California resources has become important planning and analysis activity across the Commission. As such, Electranix has been directed to evaluate transmission enhancement options that can support the delivery of new California renewable resources to load centers. Among the options Electranix has begun to evaluate include:

- Power flows from northeastern California wind resource areas.
- Power flows from southern California geothermal resource areas.
- Power flows from Mojave region solar resource areas.
- Power flows from central California wind resource areas.

This analysis will be completed in early 2005 and support 2005 IEPR activity.

**Continued: Renewable Energy Technology Research and Development Program**

**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 Schwartz (415) 554-2425

**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/Public Renewables Partnership (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 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 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.
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

**Proposed Outcomes:**

1. Over 2000 megawatts (MW) of new renewable generation to supply California.
2. Corresponding reduction in fuel price risk.
3. Offsetting emissions from traditional power generating stations.
4. Increased utilization of existing transmission assets.
5. Economic development activity in excess of \$4,000,000,000.
6. Number of developable sites identified.
7. Total capacity of identified sites.
8. Competitive economics of each site.

9. Synergies with storage, HVDC Intertie and Central Valley Project.
10. Usefulness to PRP members.

**Project Status:**

This project is ongoing, about seven month behind schedule and within budget.

In the past year, Distributed Generation Systems completed the following tasks:

- Completed Task 1.2.1: Identify Candidate New Sites. Through an iterative process involving Distributed Generation Systems., its meteorology consultants, and Commission staff, six wind energy sites were selected from an initial list of 55.
- Completed draft reports for Task 1.2.2: Candidate Site Interconnection and Economic Analysis. Prepared reports on interconnection issues and project pro formas for the 5 new sites identified above.
- Initiated Task 1.2.3: Resource Analysis and Preliminary Environmental Assessment. Began preparations for tower installation, including preparing right of way applications for tower sites.

Six wind monitoring stations sites have been identified and permitting processes have begun to facilitate met station installation.

- Two met stations have been installed in southern Oregon. Initial wind resource data is being collected.
- Permits have been received for met station sites in northeastern and central California. Met stations will be installed at these sites in early 2005.
- Two additional met station sites are still being evaluated: a southern California site northeast of LA, and an eastern Sierra site near the Nevada border. Final site selection will be made in early 2005.

**Continued: Renewable Energy Technology Research and Development Program**

**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) 554-2425

**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 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 (\$/kilowatt (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 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.
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

**Proposed Outcomes:**

1. Increase the amount of geothermal generation in California by bringing new resources on line or adding capacity at existing resources.
2. 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.
3. Increase the affordability of geothermal projects by minimizing transmission costs.

4. 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:**

GeothermEx has successfully completed this project. The final report was completed and is posted to Commission web site.

GeothermEx used the resource parameters and generation capacities previously compiled for HVDC area projects, along with statistical correlations on drilling costs vs. depth and well productivity versus temperature, to estimate a realistic set of exploration and drilling (resource confirmation) costs. Results have been compiled into several tabular report formats, which include a detailed development cost estimate report for each project area, and summary tables for all projects of total development cost, development drilling information, and development cost per kilowatt (kW), as shown below.

Estimate	Total MW	MW new plant development	Exploration (E) 1000\$	Confirmation (C) 1000\$	Develop Site (D) 1000\$	E + C + D 1000\$	(E+C+D) / kW new plant \$
Minimum	1,250	768	\$24,575	\$263,987	\$2,210,005	\$2,496,095	\$3,249
Most-likely	2,510	1,921	\$24,575	\$674,265	\$5,522,732	\$6,221,572	\$3,239

GeothermEx compiled resource parameters and operational constraints for eighteen geothermal sites in California considered too far from the High-Voltage Direct-Current (HVDC) transmission line to be considered for a potential tap into this line. Results are summarized below.

Estimate	Total MW	MW new wellhead development	Exploration (E) 1000\$	Confirmation (C) 1000\$	Develop Site (D) 1000\$	E + C 1000\$	(E+C) / kW new wellhead \$
Minimum	2,509	1,161	\$3,210	\$363,970	Future task	\$367,180	\$316
Most-likely	4,076	2,689	\$3,210	\$746,900	Future task	\$750,110	\$279

A principal outcome of the work has been the creation of the PIER Geothermal Database in MS Access. The PIER Geothermal Database includes information about the resource characteristics of 155 separate geothermal projects at 83 resource areas. It also includes embedded documents describing the methodology of the study and tables summarizing results.

Based on the reserve estimates of this study, the electrical generation capacity available to the California market from geothermal sources in California and Nevada has a minimum value of about 4,700 gross MW and a most-likely value of about 6,200 gross MW. After allowances for generation capacity already on line, the incremental generation capacity available from geothermal sources in both states has a minimum value of about 2,800 gross MW and a most-likely value of about 4,300 gross MW.

The generation capacity available from fields within California alone has a minimum value of about 3,700 gross MW and a most-likely value of about 4,700 gross MW. The incremental generation capacity available from fields within California alone has a minimum value of about 2,000 gross MW and a most-likely value of about 3,000 gross MW. Geothermal sites in California account for about 70% of the combined incremental generation capacity available from both states. Within California, 90% of the incremental generation capacity identified in this study comes from three areas: the Imperial Valley, The Geysers, and Medicine Lake. The Imperial Valley alone accounts for about 65% of the incremental capacity available in California.

For the geothermal sites in both states, the capital cost of incremental generation capacity averaged about \$3,100 per kW installed. For California sites alone, the average capital cost of incremental generation capacity was somewhat lower: about \$2,950 per kW installed. These cost estimates include the following components:

- Exploration (up to the siting of the first deep, commercial-diameter hole).
- Confirmation drilling (up to achieving 25% of required capacity at the wellhead).
- Development drilling (up to achieving 105% of required capacity at the wellhead).
- Construction of the power plant (including ancillary site facilities).
- Transmission-line costs.

The capital cost estimates are only approximate, because each developer would bring their own experience, bias, and opportunities to the development process. Nonetheless, the overall costs per project estimated in this study are believed to be reasonable.

The capital cost for specific geothermal projects ranged from about \$1,000/kW (for a small expansion at an existing project) to values in excess of \$6,000/kW (for deep, low-temperature resources at remote locations). Of the 4,300 gross MW of most-likely incremental capacity available from both California and Nevada, about 2,500 gross MW is available at a capital cost less than the average of \$3,100/kW. Considering just fields within California, about 2,000 gross MW of incremental generating capacity is available at a capital cost below the average of \$2,950/kW.

For the purposes of this study, a capital cost of \$2,400/kW or less is considered competitive with other renewable resources, both for the California/Nevada study area and for the State of California alone. The amount of incremental geothermal capacity available at or below \$2,400/kW is about 1,700 gross MW for the California/Nevada study area, and the same amount (after rounding to the nearest increment of 50 gross MW) for the State of California alone. This amount of geothermal capacity available represents a significant opportunity for commercial development to meet the needs of the California electricity market. Resources with higher estimated costs may also be attractive, depending on market conditions and the mechanisms for implementing California's renewable portfolio standard.

**Continued: Renewable Energy Technology Research and Development Program**

**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

**Contract Project Manager:** Fred Schwartz (415) 554-2425

**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 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.
- Advancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

**Proposed Outcomes:**

1. Increase the amount of geothermal utilization in California that is achievable without any exploration or new development risk.
2. 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.
3. 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 appears to be reasonable.

**Project Status:**

- Work on this project began in April 2004.
- Information collection has been slowed by geothermal operators' reluctance to release capital and operating cost data with contemplated improvements. In part, this is because the operators are getting pressure under the implementation of new federal tax regulation. The operators feel that such pressure is inappropriate and could put them at disadvantage in negotiations for future power sales contracts.
- Site visits have been made with geothermal operators in the Geysers region, Coso and northern Nevada.
- Input data is still needed for Imperial Valley plants.

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- A technical review of identified plant improvement options is planned with geothermal experts from the CEC, Idaho National Engineering and Environmental Laboratory (INEEL), National Renewable Energy Laboratory (NREL) and Sandia in early 2005.

**Continued: Renewable Energy Technology Research and Development Program**

**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 Schwartz (415) 554-2425

**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 is threefold:

- Identify the best locations for distributed generation in local utility distribution systems.
- Identify reliability impacts.
- Assess the impact of load growth and generator uncertainty.

The analysis will focus on four distribution systems: City of Palo Alto Utility's (CPAU) system, the City of Alameda's system, and two Public Renewables Partnership (PRP) member utilities' systems. The overall objective is to accelerate the deployment of renewable energy systems in a distributed generation mode by fully accounting for all benefits.

The contractor will identify at least three potential test locations in each system. Reliability impacts will be expressed using estimated incremental changes to expected unserved energy (EUE). Reliability financial values 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 a subcontractor to E3 will complete the engineering analysis.

**This 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 and 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.

**Proposed Outcomes:**

1. 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.

2. Within ten years this approach will be refined by member and other utilities to become standard industry practice.
3. 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 that satisfy the distribution company, Technical Advisors, and the Commission.

**Project Status:**

This project is ongoing and about four months behind schedule due to contracting issues. It is within budget. E3 is expected to complete this project in early 2005. In year two of this project, E3 accomplished the following:

Renewable Distributed Generation Case Studies were completed for SMUD, Alameda and Palo Alto, including the following tasks for each:

- Baseline data reports.
- Avoided cost analysis.
- Circuit modeling and load and expansion plan analysis.
- Engineering and reliability analysis.
- Economic screening and final reports.

Presentations were made to utility management and senior staff at each utility on the case study results. Individual case study tasks have begun for the City of San Francisco. This work will focus on evaluating DG opportunities and benefits at the Hunters Point Naval Station site that has been taken over by the city for new residential and commercial development.

**Continued: Renewable Energy Technology Research and Development Program**

**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 Schwartz (415) 554-2425

**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 kilowatt electric (kWe) range.
- Perform detailed engineering/economic studies of biomass plants in the 1-10 MW range.
- 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 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.

- Enhancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers.

**Proposed Outcomes:**

1. Demonstrate the economic and public benefits of using biomass resources that are largely wasted today.
2. Demonstrate the value of deploying modular biomass systems strategically within the electric transmission and distribution system to enhance its benefits.
3. 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:

1. Commission and peer acceptance of the analysis tools and methods used to characterize distributed generation opportunities and benefits of biomass generation.
2. Demonstrate 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.
3. Reduce BioMax costs of generation by 25 percent over the current state-of-the-art.
4. Develop of a small generating plant (1-10 MW in size) by TenderLand (pending favorable economic and technical analysis).
5. Successful adaptation of modular biomass generating technology, controls and operating procedures identified during the analysis to enhance the distribution generation value of projects.
6. Acceptance by consumers, TenderLand, Truckee Donner or one other public power entity of the technical, business, and marketing plans for the project.
7. Public recognition in newspapers and other media outlets of the public benefits produced by the project.

**Project Status:**

The project is significantly behind schedule. It has been re-scoped to focus on the demonstration of the smaller biomass DG unit. McNeil is now working to prepare a plan for future activities, to include:

- A final, thorough evaluation of all of the costs associated with completing the 15 kW demonstration unit, including complete installation of a waste heat recovery option.
- McNeil, with the support of TDPUD, should make every effort to secure additional co-funding from the Forest Service and other project partners.
- Where additional funds are required to complete the demonstration unit, a specific, discrete request should be made to the Program.
- Regarding the Medium Size Plant, (1-5MW project) - conduct only the initial feasibility analysis, with a focus on establishing the economic viability of the project, paying particular attention to fuel supply and cost analysis. Develop a draft Power Purchase Agreement (PPA) that would be acceptable to TDPUD (or equivalent).
- A site for the 15 kW demonstration unit has been identified at a Truckee-Donner Recreation District site in Truckee.
- The 15 kW Biomax unit has been procured and undergone factory acceptance tests
- A building shelter has been designed and necessary building and environmental permits have been prepared and filed.
- An initial supply of fuel has been identified.

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- Additional Forest Service Match Funds have been identified and committed to support the 15 kW demo.
- Installation and commissioning of the 15 kW demo is anticipated in early spring 2005.

**Continued: Renewable Energy Technology Research and Development Program**

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

**Project 4.1 Solar Thermal Parabolic Trough Power Plant**

**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 Schwartz (415) 554-2425

**Subcontractor Project Manager:** Gilbert Cohen (919) 871-0423

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

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 independent power producer (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 High-Voltage Direct-Current (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.
- 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.
- Develop, working with the municipal utility companies, a draft PPA for implementation.

**This 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 and 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.

**Proposed Outcomes:**

1. Deliver new site selection data for California for large-scale solar thermal power plants near the Pacific HVDC intertie or elsewhere.
2. Propose a construction plan for a sequence of plants up to a total of 1000 MW.
3. Show the performance and cost reductions that may be derived from a next series of projects.
4. Develop a new PPA model for large-scale solar thermal power plants.

**Project Status:**

This project is 90% complete. All project reports have been drafted and are in final review stages, as listed below:

- Site requirements analysis and report.
- Business Model and Incentives Reports.
- Economic Analysis and Draft Power Purchase Agreement.
- Project results show that bulk solar power can be economically viable where it can deliver much of the energy during system on-peak periods.
- This can be accomplished by optimal use of thermal energy storage, allowing off-peak solar energy collection to be shifted to on-peak electric energy production.
- The Final Report Outline has been submitted for review.
- The Project Final Report is anticipated in March 2005.

**Continued: Renewable Energy Technology Research and Development Program**

**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 Schwartz (415) 554-2425

**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 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 and 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.

**Proposed Outcomes:**

1. Develop a modified external burner section capable of operating on available bio-fuels within program design and economic parameters.
2. 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.
3. Field Test the prototype/demonstration unit.
4. Establish economic model for markets conditions with respect to price competitiveness (as compared to other green options and incentive driven blended green offerings). Low production price target is \$1500 per installed kilowatt hour (kWh), \$400 mass production scale. These numbers are conservatively consistent with the NASA Mod II report for natural gas fired systems.

5. 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.
6. Establish teaming agreements for product/systems with PRP members and partners, prospective co-investors, vendors and distributors.
7. Projected Alpha commercial unit has a target date of 12/31/02.
8. Projected installed units approximately 10 units and 1 MW by 12/31/03.
9. Projected 10 MW installed at year 5.
10. Projected 50 MW installed by year 10.
11. Projected 250 MW installed by year 15.

**Project Status:**

A stop work order was issued for this particular project. In March of 2004, a critical project review was held as a result of significant schedule slippages in the project. As a result of that review, Stirling Energy Systems (SES), SFPUC, Center for Resource Solutions (CRS), and Commission staff determined that there is no apparent near-term business opportunity for the 25 KWe Stirling genset. As a result, continuing further development and business planning for the technology would not be prudent or cost effective for either the Commission or SES. SES has been instructed to not perform any further technical work on the project.

Completion of the tasks to wrap up and close out the project includes:

- Completion of the deliverable for Subtask 4.2.1.4 - Report that characterizes the completion of prototype burner. This report shall cover all of the technical work performed for the Project through March 2004. Submit a draft report for review, then the final deliverable report that would incorporate CEC comments.
- Finalization of the deliverable for Subtask 4.2.2.1 – Draft Business Plan. SES had previously prepared and submitted a draft of this report. That draft should be updated to incorporate the business perspectives discussed on March 22 (the business reasons for discontinuing development at this time).
- Addressing questions and comments made by the Commission to complete the deliverable for Subtask 4.2.1.1 – Preliminary External Burner Design.

In October, SES completed and delivered review drafts of the final reports requested. These reports were finalized in December. The Project will be completed and formally closed out in early 2005.

Documentation of the successful burner design and laboratory test will serve as important baseline data for future PIER Program activities in the area of biomass combustion.

**Continued: Renewable Energy Technology Research and Development Program**

**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) 554-2425

**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 intertie 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:
    - 1) Existing hydroelectric resources.
    - 2) Batteries.
    - 3) Superconducting magnetic energy storage.
    - 4) 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 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 and 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.

**Proposed Outcomes:**

1. A corresponding amount of less environmentally friendly energy will be displaced.
2. 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.
3. Added energy from the development of renewable resources with energy storage will increase the reliability of energy supply to the California power system.
4. Provide a technical assessment on the energy storage options for the renewable energy resources identified for future development in the California -Nevada border regions.

5. 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.
6. 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:**

This project is ongoing and within budget. In the past year, the following items were accomplished:

- An Optimizing Model for Energy Storage of Wind/PV Generation was completed. This energy storage model was used to support the evaluation of the Hetchy hydro system as a wind energy firming resource within Project 5.1.
- A Critical Project Review was held in November 2003.
- The task to assemble data for the energy storage model is well underway.
- A conceptual design of an advanced Pumped Hydro Storage Plant has been completed as an element of the Bulk Energy Storage technology characterization task.
- Characterization of distributed storage technologies has begun to support the Distributed Generation Case Study for San Francisco (Project 3.1).

**Continued: Renewable Energy Technology Research and Development Program**

**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 Schwartz (415) 554-2425

**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 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 and 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.

**Proposed Outcomes:**

1. Identify at least one economically-viable HVDC/Bulk Renewables project combination.
2. Produce an integrated distributed generation assessment resulting in successful demonstration and deployment.

**Project Status:**

In December 2003, staff from the SFPUC, the Commission, and CRS conducted an evaluation concerning options for re-scoping or re-programming several tasks within Program Management and Administration (Project 0). During that process, several administrative tasks and one technical task were determined to be redundant with other project tasks. At the same time, the management team identified several new technical tasks that complimented the overall Program work scope and were a good fit with the overall goals and objectives.

The following changes were made to the work scope:

- Eliminate Final Results and Recommendations Report for the Integration Workshops.
- Add a new task, Task 5.1.4 – SFPUC/Hetch Hetchy Water and Power Strategic Energy Analysis. Included in this task are: Subtask 5.1.4.1 Strategic evaluation of renewable fuels production and use in the City of San Francisco; and Subtask 5.1.4.2 Evaluation of using Hetch Hetchy hydropower resources to “firm” wind power imports to the City of San Francisco.
- Also added to the project was a task to coordinate strategic planning processes surrounding use and development of new electric transmission needed to serve increased renewable energy development throughout the State.

The objective of the *Renewable Fuels Task* is to evaluate the potential benefits to the City of San Francisco of investing in renewable fuels production, storage, transportation and/or end-uses, and to evaluate from financial and strategic perspective potential development scenarios for such renewable fuels applications. Uses for renewable fuels could include electric power production, space conditioning, etc. Included in the assessment will be a high level economic evaluation of the incremental benefit to San Francisco of production, storage, distribution and end-uses of renewable fuels. Application of these technologies will be considered for the city as a whole, and more detailed investigation of more specific applications will be conducted in follow-on studies if warranted by the initial analysis.

The objective of the *Wind-Hydro Integration Task* is to evaluate the technical potential to use flexibility in the Hetch Hetchy hydro system to firm wind energy transmission to San Francisco (thereby increasing the total quantity of wind energy that the SF energy system can accommodate), and to evaluate the potential of such imports to replace fossil generation. This analysis will have technical and policy/economic/strategic components. Analysis of new wind plant options for San Francisco and the integration of new wind into the SFPUC supply mix will feed directly into SFPUC resource planning and acquisition strategies.

The objective of the new *Transmission Strategic Planning Task* is to create an overarching transmission planning process (the "proposed process") focused on developing statewide solutions (in contrast to STEP) and involving all transmission owners (in contrast to the CPUC/CAISO). These solutions will address California's long-term power needs, meet renewable energy goals, and coordinate with the other on-going planning efforts across the Western

Electricity Coordinating Council (WECC) (including the Northwest Transmission Assessment Committee, Northwest Transmission Assessment Committee (NTAC); the Rocky Mountain Area Transmission Study, RMATS; and the Seams Steering Group-Western Interconnection, Seams Steering Group- Western Interconnection (SSG-WI)). The process would build collaboration among the CPUC, CAISO and the Commission on the joint-agency/Energy Action Plan model, but would be initiated by the CEC because of its unique standing to incorporate the interests and concerns of public power.

- The conceptual integration of a plausible future power project; including a tap of the PDCI north of Reno, development of 600 MW of new geothermal power, and development of 1000 MW of wind power, has been developed under this project. This analysis will be characterized in the Project 5.1 Final Report.
- An initial evaluation of the use of the Hetchy hydro system to firm new wind power has been completed. Preliminary analysis suggests there is substantial firming capability in the system during the summer and fall months.
- Initial Renewable Fuel Options tasks have been completed. Waste stream conversion to bio-gas fuels and electrolytic hydrogen production appear to be attractive options for San Francisco.
- Coordination work has begun under the Tehachapi Study Group (TSG). The creation of a Study Group to evaluate transmission issues related to the Imperial Valley geothermal resource has been initiated through this project as an adjunct to the TSG.
- Work has also begun on a new Project task to evaluate the potential benefits of flexible transmission contracts, particularly for new wind development, where existing lines have no Available Transmission (ATC). Initial analysis suggests that the Western Area Power Administration transmission system in northern California may be suitable to such “conditional firm” transmission contract.

**SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**Contract #:** 500-00-034

**Contractor:** Sacramento Municipal Utility District

**Contract Amount:** \$13,649,620

**Match Amount:** \$10,549,413

**Contractor Project Manager:** Bruce Vincent (916) 732-5397

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Active

**Program 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 (like 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 learning from a structured manufacturing and installation approach that has the potential to significantly reduce 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.

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 has developed and is testing 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) has developed and is demonstrating a 20-25 kilowatt (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. National Renewable Energy Laboratory (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.

**This programmatic contract 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.
- Providing greater choices for California consumers by increasing the use of renewable energy technologies in California's electricity mix.

**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. The Renewable Programmatic Advisory Committee has held Critical Project Review (CPR) meetings. These CPRs have given valuable outside independent expert advice with favorable results. A 2002 annual review of the programmatic received a positive recommendation to proceed from the PIER Research Committee. A 2003 Annual report was received.

In general, the ReGen Program is meeting or exceeding its goals for technical developments and maintaining the budget. The Program is expected to be extended by one year to account for the late project start and additional demonstration of the funded projects. All projects have signed sub-contracts, held kickoff meetings, and are proceeding with RD&D activities. On the following pages are the project write-ups by emphasis areas.

All projects are expected to be completed by the end of 2005. Public and private web based project information is available at:

⇒ [www.smud.org/pier](http://www.smud.org/pier)

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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 Davis

**Project Amount:** \$158,070

**Match Funding:** \$20,120

**Contract Project Manager:** Bryan Jenkins (530) 752-1422

**Commission Project Manager:** Prab Sethi (916) 654-4509

**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.
- 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 objectives 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.
- 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:**

1. Identify near- and longer-term technologies for enhanced biomass power generation in the region.
2. Develop information that will increase the use of a diverse fuel mix.
3. Develop information that will reduce environmental impacts from agricultural residue and solid waste disposal activities.
4. Yield a better understanding of the means to increase generation, improve efficiency, and/or reduce costs of power from straw, municipal solid wastes, and other biomass materials available within the region.

**Actual Outcomes:**

1. Identified near- and longer-term technologies for enhanced biomass power generation in the region.
2. Developed information that will increase the use of a diverse fuel mix.

3. Developed information that will reduce environmental impacts from agricultural residue and solid waste disposal activities.
4. Yielded a better understanding of the means to increase generation, improve efficiency, and/or reduce costs of power from straw, municipal solid wastes, and other biomass materials available within the region.

**Project Status:**

Active and on budget. Two task deliverables have been received. All deliverables, including a draft final report, are expected to be completed by March, 2005. The approved version of final report is expected by the end of May, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 objectives 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.
- Improving electricity reliability, quality, and sufficiency by developing the next options for solar energy market expansion in the SMUD region.

**Proposed Outcome:**

1. 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.

**Actual Outcomes:**

1. Developed materials that will allow the CEC programs and utility programs to benefit from the TEAM-UP business model and hardware deployment program funded by the U.S. Department of Energy.
2. Obtained the best technical and market input for the planning and setting of initial goals for PV programs.
3. Developed the next options for solar energy market expansion in the SMUD region.
4. Documented SMUD's PV programs and their history and develop market-transformation materials based on this work.
5. Documented the status of PV industry in the U.S. by interviewing key people in the industry.
6. Documented national technical and market experience for application to the SMUD PV R&D program.
7. Identified possible innovative follow-on commercialization paths for California utilities for PV.

**Project Status:**

Active, on budget, on schedule and nearing completion. The project is complete except for the Final Report and Final Meeting. A draft final report is undergoing review, which will be completed by the end of March, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Richard Perez, (303) 384-6546

**Commission Project Manager:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 objectives of:**

- Improving energy cost/value of California's electricity by using geosynchronous orbiting earth satellite (GOES) 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.
- 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:**

1. Analyze:
  - PVs unquantified benefits.
  - PVs match to utility peak.
  - The benefits of orienting PV arrays to match PV output with utility demand peaks.
2. Beta test the solar load controller developed by the State University of NY.

**Actual Outcomes:**

1. Determined the benefits of PV for SMUD and its customers and presented the results to SMUD management.
2. Demonstrated the benefits and feasibility of new control options for PV and building loads.
3. Determined the benefits of various orientations for PV arrays.

**Project Status:**

Project is completed 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. The final report will be completed by the end of March, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 objectives of:**

- Improving energy cost/value of California's electricity by forming a reliable basis for calculating total hourly PV generation.
- Improving the environment, public health and safety by providing comprehensive and current information on operating health of each grid interconnected PV system.

**Proposed Outcome:**

1. A monthly exception report identifying non- and under-performing systems.
2. A database available to SMUD staff showing the health of any queried system for use with customer comments and concerns.

**Actual Outcomes:**

1. Developed and implemented the software needed to provide a monthly exception report identifying non- and under-performing systems.
2. Developed and implemented the software needed to establish a health showing of any queried system for use with customer comments and concerns.

**Project Status:**

The project is active and the performance indexing system was completed on schedule. A subcontractor has been hired to document the system so the results can be transferred to other electric utilities. The final task report and draft final report will be completed by the end of March, 2005. The project is expected to be completed by the end of June, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 objectives 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.
- 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:**

1. Develop data that will make it possible to correctly size and evaluate renewable-based air-conditioning equipment.
2. 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.

**Actual Outcomes:**

1. Developed data that will make it possible to correctly size and evaluate renewable-based air-conditioning equipment.
2. Developed 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.
3. Developed 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.
4. Developed data that will ultimately make it possible for PV to be used in mission-critical applications without being connected to the grid.

**Project Status:**

Technical work is complete with the exception of the Final Report. All technical work was completed on time and on budget. A draft final report has been received and is being reviewed.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**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 constraints, and demonstrating the environmental and economic benefits of this technology.

**This project supports the PIER Program objectives 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.
- 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:**

1. Develop a system to accelerate waste decomposition and leachate treatment, via liquid amendments and recirculation through pipe network serving the waste mass.
2. Accomplish the efficient capture of nearly all generated methane.
3. Document the capital and operations cost of a full-scale bioreactor and determine the economic viability of it commercialization.

**Actual Outcomes:**

1. Achieved acceleration of waste decomposition and leachate treatment and demonstrated that this could be accomplished without excessive leachate head build up over the base liner.
2. Accomplished the rapid completion of decomposition, stabilization and generation of methane.
3. Accomplished the efficient capture of nearly all generated methane, without an impact to the local air quality.
4. Documented the capital and operations cost of a full-scale bioreactor and determined the economic viability of it commercialization.
5. Monitored the system and documented the capital and operations costs, as well as benefits.

**Project Status:**

Technical work is complete with the exception of the Final Report. The subcontractor continues to monitor methane production to develop additional operating data. A draft final report is 75% complete. Technical deliverables were completed on schedule. Closeout activities are continuing. All work is expected to be completed by the end of June, 2005. The project is on budget.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 objectives 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.
- 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:**

1. Accommodate the widest range of residential and light commercial roofs.
2. Develop fast, easy installation methods.
3. Build an automated laminating/finishing facility to satisfy demand.

**Actual Outcomes:**

1. Designed and tested the necessary hardware.
2. Researched and developed a new packaging and product-delivery system.
3. Procured a UL listing for the laminate and batten system.
4. Developed five demonstration projects and completed monitoring of the projects.
5. Developed installation and operation manuals and videos will be developed.
6. Developed a contractor training program.
7. New manufacturing facilities for the new BIPV product were not developed. The subcontractor had financial difficulties and could not commit to the development of manufacturing facilities.

**Project Status:**

All technical work was completed on time. A final report is being reviewed by SMUD. A closeout meeting will be scheduled soon. Work was completed under budget. The project will be closed out by the end of June, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**Project Description:**

Schott Applied Power Corp. (SAPC) will develop and document Building Integrated Photovoltaic (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 objectives 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.
- Improving the environment, public health and safety by identifying focus areas and review the functional requirements for selected BIPV mounting approaches.

**Proposed Outcomes:**

1. Greater options in BIPV mounting techniques for California architects and builders.
2. Greater awareness and adoption of PV practices by architects and builders.
3. Reduced cost of installation.
4. Increased use of BIPV in new construction.

**Actual Outcomes:**

1. Did not support the use of Building Integrated PV Systems (BIPV) in new construction.
2. Did not document a specific set of approaches that can be readily adapted by design professionals on future projects.
3. Identified focus areas and reviewed the functional requirements for selected BIPV mounting approaches.
4. Developed and prototyped a residential BIPV design that meet those approaches.
5. Did not create information such as drawings and specifications that can be used by architects, designers and engineers to promote the incorporation of BIPV in new construction.

The emphasis in the project was shifted to the design and prototyping of one residential BIPV system aimed at the new construction market. The project was cancelled by mutual agreement when it became apparent that the design would be poorly received in the American market. Specifically, the PV module chosen by the subcontractor was not compatible with U.S. building practices.

**Project Status:**

The project was cancelled by mutual agreement with the subcontractor because the results showed that the resulting product would not be accepted by the residential building industry in the U.S. A draft final report has been received. All closeout activities will be completed by the end of June, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 that significantly decreases 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.

Specific goals for this project are:

- 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.
- Be certified by Underwriters Laboratories (UL), International Conference of Building Officials (ICBO), and Institute of Electrical and Electronics Engineers (IEEE).

**This project supports the PIER Program objectives 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.

**Proposed Outcome:**

1. Develop a new residential PV roofing product that will:
  - Be designed for retrofit and building-integrated applications.
  - 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.
  - Contain integrated electrical wiring and interconnection into the mounting system, which will be accessible after installation.
  - Have electrical and thermal performance that could obtain recognition by CEC Title 24.
  - Have a 50-year design life and increased roof durability.

**Actual Outcomes:**

The original scope of work called for the development of one new PV product. The subcontractor has met all of the original goals while developing four new PV products that meet all 5 proposed characteristics:

1. A residential BIPV product.
2. A revised module for use in all of the manufacturer's products.
3. A non-roof-penetrating, non-ballasted PV system for residential flat roofs.
4. A PV system for commercial-sector flat roofs with tilted modules.

**Project Status:**

Technical work is complete with the exception of two deliverables and the Final Report. The project is on schedule and on budget. The closeout meeting will be completed by the end of June 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 objectives 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.
- 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:

1. Greater choice for purchasers of PV systems.
2. Reduced cost of installation.
3. Increased flexibility for deploying PV systems.

**Actual Outcomes:**

1. Developed a mounting approach that allows modules to easily be mounted on a flat rooftop.
2. Eliminated the use of additional ballast materials and numerous penetrations.
3. Achieved a mounting system with low cost, ease of assembly, modularity and adaptability to a wide range of uses.
4. The subcontractor brought the product to market and has achieved PV installations that are estimated to be in excess of 2 MW.
5. Additional funding was provided to the project for additional wind-tunnel testing to ensure good performance of the mounting system in high winds striking the PV array from a variety of directions. The wind-tunnel testing was successful.

**Project Status:**

The project is complete except for approval of the final report and completion of a closeout meeting. Completion is expected by the end of June, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**Project Description:**

AstroPower 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, AstroPower 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.
- 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:
  - Track the array maximum power point.
  - Invert DC to AC power at no less than 93% efficiency.
  - Operates through a wide range of DC input voltages to enable single-string arrays of various sizes.
- Incorporating all AC and DC switching and protective devices and designing flexibility, such as array size and battery usage.

**Proposed Outcomes:**

1. Research and develop a PV module/laminate product and associated mounting and wiring system that:
  - a. Will be accepted by mainstream consumer markets.
  - b. Reduces or eliminates penetrations of the roofing membrane (flashed “feet”) for new construction.

- c. Functions as part of a weatherproofing system, though not necessarily a “Building Integrated PV” product.
- d. Presents an appearance that is more consistent with conventional roofing, and minimizes or eliminates the visibility of mounting or wiring hardware from the ground.
- e. Works with the majority of the roofing products predominant in sloped-roof residential construction in California, including Spanish tile and concrete tile.
- f. Eliminates the need for inter-module hardwiring and conduit on the roof.

**Actual Outcomes:**

- 1. Researched and developed an advanced PV module/laminate product and associated mounting and wiring system.
- 2. Researched but did not develop an advanced Power Conditioning Unit (PCU) for grid-connected PV systems.
- 3. Researched but did not develop an advanced low-cost PV system meter appropriate for the new module/laminate, PCU, and system design configuration.
- 4. Did not integrate the advanced module/laminate, PCU, and meter elements into a line of packaged residential PV systems.
- 5. For the residential BIPV market, improved performance, aesthetics, functionality, usability, and reduce consumer cost by approximately 20%.

**Project Status:**

A residential BIPV system was developed and marketed. Upon the subcontractor’s financial failure, the product was acquired by General Electric and is the only PV product used by production builders for the past two years. This product has sustained PV in the residential new construction market and is the basis for new zero energy home efforts. The power Conditioning Unit (PCU) for grid-connected PV systems was cancelled because a number of new products were being introduced by other manufacturers. The low-cost PV system meter was cancelled because product-development activities showed that the price of the meter would be too high.

All work except for the final report and closeout meeting has been completed. SMUD is negotiating with General Electric for a final report. GE acquired the R&D staff that developed the BIPV system. The project is under-budget and all work was completed on time. The project is expected to be completed by the end of June, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 and produce sufficient electricity, if aggregated, to be of interest as spot-market generators.

**This project supports the PIER Program objectives 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.
- Improving electricity reliability, quality, and sufficiency by developing PV-powered irrigation systems designs and demonstration projects.

**Proposed Outcomes:**

1. Create the basis for a PV agriculture irrigation program in the Sacramento area.
2. Test market for remote dispatch of PV systems in agricultural applications.
3. Evaluate the need for battery storage for a variety of situations.
4. Design systems with optimized PV and battery sizing.
5. Implement two demonstration projects – one grid connected and one grid independent.

**Actual Outcome:**

1. The subcontractor was successful in implementing several very large PV systems for water wells in other parts of California, eliminating the need for an R&D project.

**Project Status:**

The project will be cancelled, because:

1. SMUD was unable to locate an agricultural site for a 20 – 30 kW system. Depressed agricultural sectors (wine grapes, dairies) and low electric rates (compared to the California IOUs) were the cause.
2. The end of the energy crisis eliminated the possibility of testing a PV-dispatch program within the time frame of the project.

The process is expected to be complete by the end of March, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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.
- (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 objectives 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.
- Providing greater choices for California consumers by monitoring and evaluating the demonstration projects. Building a DC-operated indirect/direct evaporative cooling unit.

**Proposed Outcomes:**

1. Complete a demonstration project with 115VAC PV and a 115VAC evaporative cooling unit.
2. Complete a demonstration project with 115VAC/48VDC PV and a 48VDC evaporative cooling unit.

**Actual Outcomes:**

1. Completed a demonstration project with 115VAC PV and a 115VAC evaporative cooling unit.
2. Completed a demonstration project with 115VAC/48VDC PV and a 48VDC evaporative cooling unit. The system is operating in the 115 VAC mode.
3. Implemented a new generation of indirect/direct evaporative coolers in two demonstration projects.
4. Developed and built a DC-operated indirect/direct evaporative cooling unit.

**Project Status:**

The project is behind schedule because of the slow permitting process and the failure of a PV manufacturer to deliver modules created delays. The project was also over-budget but SMUD has added funding to support the project. The building permits have been approved. The evaporative cooling units and all PV materials have been installed except for a set of modules. A new standing-seam sheet metal roof was installed to accommodate the two PV systems. All installations will be completed by the start of summer 2005. The project is expected to be completed by the end of November 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**Project Description:**

SAIC is proposing to develop a 20-25 kW solar dish/Stirling system and design a solar dish/photovoltaic system. This work expands upon previous SAIC dish/PV programs and the results from other design work.

**This project supports the PIER Program objectives of:**

- Providing greater choices for California consumers by utilizing a solar dish/Stirling system.
- 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:**

1. Integrate the proven SAIC solar concentrating dish with the 25 kW STM Beta Stirling engine. Achieve 22% solar conversion efficiency with 90% availability.
2. Further the reliability and experience in working with both dish/Stirling and dish/PV systems.

**Actual Outcomes:**

1. Integrated the proven SAIC solar concentrating dish with the 25 kW Kokums 4-95 Stirling engine.
2. Integrated the SAIC solar concentrating dish and the 20 kW Australian Solar Systems Limited PV receiver.
3. Did not achieve the desired conversion efficiencies or availability.
4. Did not implement a demonstration project in Sacramento but, rather, continued to operate and monitor the dish/Stirling system at its development site in Arizona, saving at least \$200,000.
5. Monitored and evaluated the systems.

**Project Status:**

All technical tasks have been completed and a draft final report has been received. The project will be completed by the end of March, 2005. All work was completed on schedule and all tasks were completed on-budget.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 objectives of:**

- Improving energy cost/value of California's electricity by demonstrating that low-cost non-vacuum processing can yield large and efficient PV modules.
- 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:**

1. Develop the equipment and processing parameters necessary to fabricate efficient larger-area monolithic multi-cell modules using particles-based non-vacuum processes.
2. Demonstrate that low-cost non-vacuum processing can yield large-area PV modules with state-of-the-art sunlight-to-electricity efficiencies.

**Actual Outcomes:**

1. Developed thin-film fabrication processes which have produced 300 cm<sup>2</sup> modules with conversion efficiencies of 7.2% and above.
2. Demonstrated that low-cost non-vacuum processing can yield PV modules with adequate (and state-of-the-art, considering the newness of the technology) sunlight-to-electricity efficiencies.

**Project Status:**

The project is active and on schedule. A draft final report has been received. All work was completed on-schedule and on-budget. Closeout is expected by the end of April, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 objectives 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.
- 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:**

1. Develop a low cost grid-feeding inverter incorporating both maximum power point tracking functions and backup power capabilities that maximizes the value of renewable energy systems with energy storage.
2. Develop a remote dispatchability capability for renewable power systems. The dispatch capability will be demonstrated in field trials to verify the effectiveness of customer sited renewable power systems as an energy management tool.

**Actual Outcomes:**

1. Developed a low cost grid-feeding inverter incorporating both maximum power point tracking functions and backup power capabilities. The inverter is presently undergoing beta testing. After two initial problems, it is operating reliably.
2. Developed a remote dispatchability capability for renewable power systems. The field trial has not yet been performed.

**Project Status:**

The project is active and on budget but is about four months behind schedule because the beta test site at SMUD’s Hedge Substation was completed later than expected. The development of the inverter is going well.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**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 thermo-photovoltaic 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 objectives 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.
- 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:**

1. Define region-specific deployment requirements, compile information on resource availability; and determine environmental, permitting, and building code constraints.
2. Develop a demonstration plan that addresses region-specific deployment requirements.
3. Select a demonstration site.
4. Develop a systems-level integration strategy and associated schedule.
5. Develop a building installation strategy and schedule.
6. Develop and coordinate modifications to a new commercial office building, develop building integration techniques, and install/troubleshoot hardware.
7. Demonstrate the technology to federal, state, and local stakeholders.

**Actual Outcomes:**

1. Selected the SMUD Customer Service Center building as the demonstration site. SMUD will build a kiosk and display to accompany the rooftop installation and will provide tours for interested parties.
2. Developed a systems-level integration strategy and associated schedule.
3. Developed a building installation strategy and schedule for the SMUD site.

4. Developed modifications to the building. SMUD is concerned about performing roof penetrations in the winter and the installation is on hold until April. The project has also been delayed by the reluctance of general contractors to bid on such a small SMUD project.
5. Have yet to demonstrate the technology to federal, state, and local stakeholders because the installation is not complete.

**Project Status:**

The project is active and behind schedule because of the problems in obtaining a contractor and concerns about performing the installation during the rainy season. Installation is tentatively scheduled for end of April, 2005, and the project is expected to be completed by the end of November, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**Commission Technical Lead:** Hassan Mohammed (916) 651-9855

**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 inexpensive 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 objectives 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.
- 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 Outcome:**

1. Develop a new generation of low-cost renewable technologies for tomorrow's electricity system.

**Actual Outcomes:**

1. Improved the practicability of reflective optics by introducing the lens-like reflective (slat-array) concentrator concept and adapted it for uniform illumination of photovoltaic cells at moderate sunlight concentrations.
2. Developed and tested a novel slat-array module with probable increased efficiency and reduced cost of operation.
3. Determined that it is technically and economically feasible to fabricate and use a slat-array module based on lens-like reflective optics.

4. Validated the novel slat-array design.
5. Built and successfully tested a 500 W slat-array system.

**Project Status:**

All technical work has been completed and a draft final report has been received. SMUD is reviewing the final report. All work was completed on time and on budget. Closeout activities will be completed by the end of June, 2005.

**Continued: SMUD/CEC Renewable Generation RD&D Program (ReGen R&D)**

**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:** Prab Sethi (916) 654-4509

**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 objectives of:**

- Improving the energy cost/value of California’s electricity by developing a lower-cost wind turbine.
- Improving the environmental, public health, and safety of California’s electricity by making wind-generated electricity more cost effective.
- Connecting to near-term market applications by working with an established wind power development team to develop a technology intended to enter the market within a few years.

**Proposed Outcomes:**

1. Engineer a commercially-viable gearbox that will either enable retrofit of existing turbines or will become the center of a new turbine design.
2. Provide full cost-scaling data for this gearbox design.
3. Construct the DGD system.
4. Integrate the DGD controller (presently in development under CEC funding).
5. Test the DGD system on the NREL test stand.

**Actual Outcomes:**

1. Engineered a potentially commercially-viable gearbox is the basis of a new turbine design.
2. Provided full cost-scaling data for this gearbox design.
3. Constructed the DGD system.
4. Integrated the DGD controller.
5. Tested the DGD system on the NREL test stand.

**Project Status:**

Based on progress made in this project, Clipper has received significant additional funding and is developing a commercial product. The project is active. Technical work was completed on time and on budget. All technical deliverables have been received. A final report is expected during the next three months.

**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:** \$1,261,980

**Contractor Project Manager:** Scott Haase (303) 980-1969

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Active

**Project Description:**

The PIER Renewables area is investigating the ability of renewable resources to help make California's electricity system more reliable, affordable, diverse and cleaner. Part of that effort involves assessing the types and magnitudes of problems that may be encountered in the State's electricity system in the future. Another part of that effort involves assessing the amounts, locations and characteristics of renewable resources that could possibly be used to help resolve the identified electricity system problems. Due to the large amount of data and the complex nature of the issues being addressed, the assessments will be conducted using power flow models and Geographical Information Systems (GIS). The purpose of this contract is to simulate the condition of California's electricity system in the future to identify possible capacity, congestion or reliability problems that could potentially be addressed using renewable energy resources. The work will involve identifying the locations and magnitude of the potential electricity system problems, the amounts and power generation characteristics of renewable energy sources that could possibly help address the problems, and the impacts of injecting renewable electricity generation into the problem areas. Moreover, in combination with the GIS work under a separate contract (Department of Forestry: 500-00-030), the results will be used to assess possible economic and environmental benefits resulting from deployment of renewables to help address the electricity problems. Lastly, the combined results will be used to develop economic, technical and environmental research and development targets for future renewable energy technologies.

**This project supports the PIER Program objective of:**

- Improving the reliability/quality of California's electrical system by identifying the locations and characteristics that will best enable renewable electricity systems help alleviate electricity capacity, reliability 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.

- 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 has been performed to develop datasets for power flow modeling of California's electricity system and power flow model simulations of California's hot spots.
- The McNeil Contract related to the Strategic Value Analysis was signed by the General Services on January 29, 2002.
- A kick off meeting was held on May 17, 2002 with McNeil Technologies and subcontractors to review scope of work and administrative items.
- Critical Project Review/project progress meeting have been held to review tasks 2.1 and 2.2 to discuss preliminary results of power flow modeling, and technology characterization.
- Task 2.1 – Power flow Modeling:
  - Data was compiled for summer peak power flows for 2003, 2005, 2007, 2010 and 2017. DPC has worked on simulation of hot spot, power flow modeling and analysis of wind, geothermal and solar locations. Locations for wind, geothermal and solar technologies have been identified. Work is continuing for the biomass resources.

**Task 2.2 – Technology Characterization and Targets**

McNeil has submitted a draft copy of the Strategic Value Analysis of Renewable Power Technologies report. McNeil has also submitted preliminary economic models for wind, geothermal and solar technologies. Work is being finalized for this task.

**Project Status:**

The contract amendment was approved by DGS on December 30, 2003. This contract was amended to add \$531,980 for a total budget of \$1,261,980 so that renewable resources can be identified to address requirements of SB 1078 to provide 20 percent of the retail sales from renewable electricity resources by 2017. McNeil is being directed to provide specific tasks, such as benefit analysis for wind and geothermal technologies.

McNeil has submitted public benefit analysis for wind and geothermal technologies in California. These documents are being reviewed by the energy Commission project leads. DPC has submitted solar technology analysis after receiving input from CDF.

## 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 (NREL) : University of California, Davis

**Contract Amount:** \$983,653

**Match Amount:** \$1,733,031

**Contractor Project Manager:** Edan Prabhu (949) 380-4899

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Active

### Project Description:

The purpose of this project is to design, develop and demonstrate a microturbine (i.e., the Flex-Microturbine™) capable of generating very clean electricity while being powered by a variety of gaseous waste fuels. To date, gaseous waste fuels (i.e., biogas fuels) have been difficult to use for electricity generation due to their relatively low energy contents and high air-pollution emissions. In turn, these problems have contributed to biogas projects being marginally economic. The biogas fuels to be demonstrated in the Flex-Microturbine™ include:

- Biogas generated from anaerobic digestion of livestock manure.
- Producer gas generated from thermal gasification of orchard and forest residues.
- Biogas from landfill gas recovery system.

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, the Contractor will design, develop and demonstrate a proof of concept (POC) and three Flex-Microturbine™ prototypes. 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 SMB initiative are feasibility and preliminary design stages, respectively. Phases 1 and IA have been completed and funded through NREL/US DOE.

This new Flex-Microturbine™ is intended to act as a safe, reliable, clean, cost-competitive provider of renewable energy with particular value to California's deregulated electricity marketplace.

### This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by generating clean electricity from waste fuels.
- Improving the environment and public health cost/value of California's electricity by mitigating air quality impacts and reducing environmental risks.
- Improving the reliability/quality of California's electricity by developing a new distributed generation technology.

### Proposed Outcomes:

1. Design, develop and demonstrate a Flex- Microturbine™ that can run on low pressure and low British thermal unit (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 system.

A. Proof-of-Concept (POC):

The following activities will demonstrate that a fuel and air mixture of 100 Btu/standard cubic feet (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 nitrogen oxides (NO<sub>x</sub>) and hydrocarbons.
- 3) Measure temperatures, pressures, output and other pertinent performance parameters.

B. For Prototype 1 (Digester Gas and Demonstration Unit):

- 1) Conduct shop tests as in POC.
- 2) Demonstrate safe startup and shutdown.
- 3) Demonstrate ability to accept fuel gas at less than 0.25 pounds per square inch, gauge (psig).
- 4) Operate for 7 days on digester gas.
- 5) Ammonia-free NO<sub>x</sub> emissions below 9 parts per million (ppm) (15 % oxygen (O<sub>2</sub>)).
- 6) Attain at least 25% gas-to-electricity efficiency (13,684 British thermal unit (Btu)/kilowatt hours (kWh), Lower heating value (LHV)).
- 7) Ability to load follow (operate at different loads, 20% to 80% capacity).
- 8) Ability to handle wide variation in fuel Btu content (200 to 800 Btu/scf).

C. For Prototype 2 (Wood Gasifier Prototype and Demonstration Unit):

- 1) Demonstrate capability to operate for at least 8 hours at a time for 5 days in a row.
- 2) Demonstrate ability to accept gas at below 0.25 psig.
- 3) Demonstrate safe startup and shutdown.
- 4) Demonstrate capability to run on gas with normal rated gasifier output (112 Btu/scf, 5 ppm tar, 5 ppm particulates).
- 5) Attain at least 25% gas-to-electricity efficiency (13,684 Btu/kWh, LHV).
- 6) Ability to handle gas Btu variations (with a minimum of 100 Btu/scf).
- 7) Ability to run on below normal gas quality (100 Btu/scf gas) for 8 hours.
- 8) Test ability to run three Flex-Microturbines running on one gasifier.
- 9) NO<sub>x</sub> emissions below 9 ppm (@15 % O<sub>2</sub>).
- 10) Particulate emissions below 0.02 lb./megawatt hours (MWh).

D. For Prototype 3 (Landfill Gas Prototype and Demonstration Unit):

- 1) Demonstrate safe startup and shutdown.
- 2) Attain at least 25% gas-to-electricity efficiency (13,684Btu/kWh, LHV).
- 3) Demonstrate ability to accept gas at below 0.25 psig.
- 4) Operate continuously for 30 days.
- 5) NO<sub>x</sub> emissions below 9 ppm (@15 % O<sub>2</sub>).
- 6) Particulate matter up to 10 micrometers in size (PM10) Particulate emissions below 0.02 lb./MWh.
- 7) Demonstrate ability to run on gases as low as than 100 Btu/scf for 24 hours.

2. Develop the Flex-Microturbine™ to provide cost competitive renewable energy in a deregulated electricity marketplace.

- A. The Flex-Microturbine™ will be available for about \$400 a kilowatt (kW). This price assumes the global sales of microturbines over 10,000 a year.

- B. 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 kilowatt hours (kWh) with a capacity factor of 90%.
- C. 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.
- D. 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.

**Proof-of-concept:**

- POC unit was demonstrated to operate:
  - Up to 15 kW, in steady state under manual control.
  - On natural gas diluted with air down to 1.5 percent methane up to 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 to monitor contractor performance.
- Approval was provided to the contractor to start the next phase of this project, which consists of design and testing of prototypes 1 and 2.
- Prototype 1 (Digester Gas):
  - The design for the prototype has been upgraded to accommodate significantly greater volume of needed catalyst.
  - Prototype 1 was tested at Capstone's test facilities. The prototype has been running for more than 1400 hours to check life of catalyst. However, the control system was unstable, and needed additional work for startup and transient control. A small amount of unburnt gases was bypassing the catalyst through a leakage path in the microturbine.
    - The project is being field tested at the Inland Empire Utility Agency's facility in Fontana, CA.
- Prototype 2 (Wood Gasifier):
  - The design for Prototype 2 will be similar to Prototype 1.
  - A 15 kW gasifier has been delivered by the Community Power Corporation (CPC) to the Energy and Environmental Research Center (EERC) in Grand Forks, ND. CPC has supplied gas filters with 50% additional surface area to control filter clogging.
  - The testing is behind schedule because the microturbine has not been delivered to EERC.

The contract completion date is March 31, 2004. The microturbine assembly and testing has been affected due to loss of Capstone persons working on the Flex turbine. A critical project review meeting was held on January 7, 2004 to monitor future project direction. It was decided to provide one year no-cost time extension to the contractor, who indicated that he can complete this project with this extension. Contractor is trying to finish this project by the contract completion date.

## Valley Fig Growers Anaerobic Digester

**Contract #:** PIR-02-005

**Contractor:** Valley Fig Growers

**Subcontractors:** Provost & Pritchard Engineering Group : Williams Engineering Associates : Capstone Turbine Corporation : Capstone Turbine Corporation

**Contract Amount:** \$476,002

**Match Amount:** \$731,223

**Contractor Project Manager:** Mike Emigh (559) 237-3893

**Commission Contract Manager:** Zhiqin (Jessica) Zhang (916) 654-4063

**Status:** Active

### Project Description:

The purpose of the project is to design and construct an anaerobic digester at Valley Fig Growers (VFG) to pre-treat wastewater prior to disposal in the municipal sewer system and create an economically feasible solution to energy and waste issues facing food processors.

The project will convert organic waste/wastewater into biogas that will be used to fuel a micro turbine or boiler to produce electricity and heat for use at the facility. The digester will reduce the concentration of the wastewater sent to the municipal sewer system, reducing the cost of wastewater disposal for VFG. Additional economic benefits will be gained from producing energy that will allow a reduction in the utility bills.

Although California is the largest agricultural state in the nation, the food processing industry has a limited number of successful digesters and is currently paying a high cost for waste/wastewater discharged to the city. The VFG project will be a showcase project that will demonstrate to other food processors the quantifiable benefits gained by installing and operating a digester. The project will allow the economic and environmental benefits of anaerobic digestion of wastewater to be observed by other companies.

### This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by converting organic waste/wastewater into biogas that will be used to fuel a micro turbine or boiler to produce electricity and heat.
- Improving the environmental and public health costs/risk of California's electricity by reducing the concentration of the wastewater sent to the municipal sewer system and by reducing the cost of wastewater disposal for VFG.

### Proposed Outcomes:

1. Generate 25 to 65 kilowatts (kW) of electricity for use on-site.
2. Save an annual cost of \$100,000/yr that VFG currently pays to Fresno for discharging wastewater into the municipal sewer.
3. Utilize 50%-100% of the waste heat from the micro-turbine to provide heat to the digester, heat facility processing water, and/or the VFG dehydrator.
4. Reduce offsite solids disposal from two truckloads per day to one per day.

### Project Status:

The project is currently within the schedule and budget and expected to be completed by March 2006. The lagoon double liners, cover, and gas mixture pipeline were installed. The project is

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currently working on installation of the microturbine and heat exchangers, underground pipe construction, and electrical construction. Overall, the project has been progressing well in meeting the Energy Commission's expectations and scope of work. The project team members have been very responsible in providing high quality products to meet the Commission's requirement. The project construction is expected to be completed by March 2005.

## Wind Energy Resource Modeling and Measurement

**Contract #:** 500-03-006

**Contractor:** AWS Truewind, LLC

**Contract Amount:** \$424,500

**Contractor Project Manager:** Bruce Bailey (518) 437-8655

**Commission Contract Manager:** Mike Kane (916) 654-7119

**Status:** Active

### Project Description:

In a previous project for the California Energy Commission entitled “New Wind Energy Resource Maps of California,” Contract #500-01-009, TrueWind Solutions used its advanced MesoMap system to produce highly detailed maps and data files of the State’s wind energy resources. The underlying purpose of the project was to encourage the development of wind energy in the State by helping companies and individuals identify promising wind project sites with a minimum of effort. The maps were validated using wind measurements from 266 locations throughout the State, including airports, ocean buoys, and towers instrumented specifically for wind resource assessment. This validation process determined that the mean wind speed estimates were accurate to within a standard error of about 0.4-0.6 m/s, or 6-8%, at a height of 50 m above ground.

Although the new maps and data files represent a major advance over the previous understanding of the states wind resources, there is room for improvement. A standard error of 6-8% in mean speed implies an uncertainty margin, with 95% confidence, of roughly 20-30% in wind turbine output. In the final report of that project, TrueWind Solutions identified several issues affecting the accuracy of the wind resource estimates and presented the following recommendations for further research:

1. High-resolution modeling of selected areas. Certain aspects of California’s unusually complex wind regime, such as blocking by coastal mountains and channeling through narrow passes, could not be modeled very accurately at the 2 km grid scale of the MASS simulations. Higher resolution MASS runs could improve the accuracy of the wind resource estimates in promising areas as tests carried out by TrueWind Solutions have shown.
2. Analysis of boundary layer issues. The stability of the nighttime boundary layer has a major impact on the wind resource in certain parts of California, particularly the desert, where it may insulate the surface from high winds aloft. However, it poses a significant modeling challenge that could not be fully explored in the previous project. In-depth research on methods of simulating stable atmospheric conditions could substantially improve the accuracy of the wind maps in such areas.
3. Measuring the wind aloft. Most of the towers that provided data for the validation of the maps were less than 20 m tall, and lack of knowledge of the wind shear above that height consequently introduced a large uncertainty in the wind resource that would be experienced by modern wind turbines. New measurements using taller towers, which are expensive, in promising areas are clearly needed. However, even the current standard 50 m towers do not reach the hub height of modern turbines (typically 70 to 80 m) let alone the tops of their blades, which may reach 130 m above ground. Existing communication towers, however, can offer a relatively inexpensive platform from which to take direct wind measurements at relevant heights in the vicinity of 100 m above ground. New techniques such as sodar can measure the wind to heights of 200 m or more at a moderate cost. In addition to exploring the wind resource at a particular site, sodar could be useful

in validating and refining models to simulate the boundary layer, with benefits in other areas being mapped.

The overall goal of this project is to improve the accuracy of wind resource estimates in promising areas of the State by addressing the three issues outlined above. This is to be a comprehensive, integrated program of measurement and modeling. Five promising areas in the State will be selected. Two of these will be in major known wind resource areas such as Tehachapi or Altamont Pass where an abundance of data is already available. The others will be in relatively unexplored areas (with a variety of types of terrain) showing promise for wind energy development. The measurement program will include very tall towers (with co-funding to the Commission provided by the US Department of Energy's State Energy Program) as well as sodar. The modeling will involve running MASS (Mesoscale Atmospheric Simulation System) at high resolution to improve the simulation of mountain blocking and channeling, as well as downslope flows, while using data from tall towers and sodar to validate and improve the boundary layer formulations.

The high-resolution wind mapping project was initially designed to encourage the development of wind energy in the State by helping companies and individuals identify promising wind project sites with a minimum of effort. By coupling computational capability with site measured data for validation, the new State maps provide a valuable resource in the absence of historical met tower data. With successful completion of this project, the State will possess one of the highest resolution maps at 200m with regional refinements at the 100m level. These refinements are expected to increase the overall accuracy of the maps by 50%. The State will have contributed to improving the accuracy and refinement of a state-of-the-art technology for providing wind mapping and forecasting services to industry. This project is expected to increase wind market penetration by small and large wind technologies. The project will provide the first wind data using sodar technology for the State and will extend our understanding of upper wind characteristics from typical 50m to 200m.

**This project supports the PIER Program objectives of:**

- Improving the reliability and quality of California's electricity by more accurately defining wind resources in the State and identifying areas of untapped wind potential.
- Improve the energy cost/value of California's electricity by providing better understanding of wind resources and helping to increase market penetration levels through coupling numerical modeling capabilities with met tower monitoring.

**Proposed Outcomes:**

1. Generate high-resolution wind resource maps targeting areas of complex terrain and meteorology.
2. Provide measured wind data and winds aloft data that will be publicly accessible.

**Project Status:**

The project was started in September, 2003. High resolution model runs of focus areas have been completed. Sodar measurement of winds aloft was completed in August 2004. Tall tower measurement is somewhat behind schedule due to difficulties securing permission from existing tall tower owners. However, all tall tower anemometers were installed and operating by August 2004 and will continue to collect data until September, 2005. This is not expected to delay completion of the project. Boundary layer research continues, and is now incorporating tall tower and sodar data into the study.

## **REN Projects Completed in 2004**

## California Wind Energy Consortium

**Contract #:** 500-00-029

**Contractor:** University of California, Davis

**Subcontractors:** Dynamic Design

**Contract Amount:** \$537,882

**Contractor Project Manager:** C. Van Dam (530) 752-7741

**Commission Contract Manager:** Dora Yen (916) 653-4128

**Status:** Completed

### Project Description:

Based on input from California's wind energy industry, the PIER program determined a need to establish a forum in which issues critical to further wind energy development in the State could be addressed and coordinated among the key stakeholders. The purpose of this project is to establish a wind energy collaborative that brings together key stakeholders with a specific focus on further beneficial development of California's wind energy resources. As such, the Collaborative will represent the first statewide and California-focused effort at tying together activities on wind energy research and development, commercialization, critical path analysis and education to help resolve key technical, environmental, economic or institutional barriers.

Collaborative members include representatives from the wind energy industry, Energy Commission staff involved in wind energy development, U.S. Department of Energy (DOE)/National Renewable Energy Laboratory (NREL) staff, members of the environmental community and representatives from the academic and research communities conducting wind energy research. A primary goal of this project is to establish and plan the self-sustaining efforts of the California Wind Energy Collaborative. Ultimately, the collaborative will provide expertise to the Commission to help supplement and enhance wind energy planning and development programs specific to California.

Additional goals include:

- Support the existing wind industry by maintaining an electronic wind performance database.
- Develop a wind energy technician training plan.
- Prepare investigative white papers reporting on current industry issues and research scenarios.
- 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:
  - Ensuring California maintains a competent and current wind energy support base.
  - Providing immediate expertise to PIER planning activities in areas pertaining to wind energy technology from design, operation/maintenance, electrical generation and management.
  - Providing immediate expertise to evaluate and assess industry requests.
- Strengthening the California economy by:
  - Supporting research and development by gathering and disseminating data pertinent for the further development of wind technologies.
  - Creating new jobs/position and training new technicians and engineers to support the wind industry.

- Providing greater choices for California energy consumers by providing current and reliable facts on the wind industry, dispelling myths about wind energy, and providing better understanding of the wind industry's capabilities by combining energy resources through case studies and optimization scenarios.

**Proposed Outcomes:**

1. Establishment of the California Wind Energy Collaborative as a forum for a coordinated approach to deal with wind related technologies beneficial to California's unique needs.
2. Help plan guidelines for a statewide wind-engineering technician training program to ensure California maintains a competent support base.
3. Investigative white papers that offer plausible approaches to optimizing wind plant facilities including RPS integration issues, storage technologies, wind trend analysis and turbine performance and power trends.
4. Assistance in planning for a State wind anemometer loan program and personnel to support the effort.
5. Continue enhancing the electronic reporting efforts of the Wind Project Performance Reporting System (WPRS).
6. Support consumer education efforts.

**Project Status:**

The California Wind Energy Collaborative established an office on the UC Davis campus in the first quarter of 2002, and is currently serving as a focal center for wind energy related developments in the State. During its first year, the Collaborative established and held semi-annual meetings of an advisory board of wind industry professionals, the wind energy research community and government representatives working on wind energy issues at the state and federal levels. In December of 2002 and 2003, the Collaborative hosted the Wind Industry Forum, which was well received by the attendees. The Collaborative continues to maintain and develop the electronic Wind Performance Reporting System (WPRS). Five scenario-based white papers have been completed: *Wind Speed and Electric Power Trends*, *Value of Back-up and Energy Storage*, *Renewable Generation Integration Cost Analysis*, *Wind Facts and Fiction*, *Geothermal Integration Issues for RPS*. In response to industry needs, the Collaborative provided initial plans for a technician training program and wind anemometer loan program. Future activities of the Collaborative will be funded under a work authorization under the University of California Office of the President/California Institute for Energy & Environment (UCOP/CIEE) Master Research Agreement. Information regarding the California Wind Energy Collaborative, including the electronic WPRS and Wind Forum proceedings can be found at:

⇒ <http://cwec.ucdavis.edu>

## Clean Power Estimator

**Contract #:** 500-01-029

**Contractor:** Clean Power Research

**Subcontractors:** Clean Power Research

**Contract Amount:** \$43,500

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

**Commission Contract Manager:** Elaine Sison-Lebrilla (916) 653-0363

**Status:** Completed

### Project Description:

The goal of this project is to assist California consumers evaluate 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.
- c) Integrating the analytical capability into the Commission's version of the Clean Power Estimator program.

### This project contributes to the PIER program objective 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 structures or generate their own electricity.

### Proposed Outcome:

1. Extend 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.

### Actual Outcome:

1. Extended 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.

### Project Status:

The Contractor has completed the 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 has been completed. The project results are available on the web at:

⇒ <http://www.consumerenergycenter.org/renewable/estimator/index.html>

## Collins Pine Co. BCI Cogeneration Project

**Contract #:** 500-98-043

**Contractor:** Collins Pine Company

**Subcontractors:** BC International Corporation : 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 (Jessica) Zhang (916) 654-4063

**Status:** Cancelled

### 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 supports the PIER Program objectives 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.
- Maximizing market/economy connection by providing positive impacts to California local economies by the creation of new jobs and new tax revenues in a rural area.

### Proposed Outcomes:

1. Determine whether the ethanol facility can produce up to 20 million gallons per year of ethanol from softwood feedstock using BC International (BCI) technologies.
2. 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.
3. Identify at least one co-product, other than lignin or ethanol, which can be produced by the ethanol facility.
4. Reduce the cost of electricity production at the Collins Pine biomass power plant by at least 1.5 cents/kilowatt hours (kWh).
5. 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 contract was terminated on April 14, 2003.

In October of 1998, the Commission signed a contract with Collins Pine Company to fund a research, development, and demonstration project under the Public Interest Energy Research (PIER) program. The total PIER budget for this contract is \$1,148,961. The match funding of \$375,274 is provided by Department of Energy (DOE)/National Renewable Energy Laboratory (NREL). The project was originally scheduled to be completed by December 2000. The project completion schedule was extended to December 31, 2001.

The Energy Commission issued a stop work order to this contract on September 19, 2001 due to lack of deliverables from subcontractors, in particular BC International (BCI). The Commission sent a stop work order follow-up letter that included a list of lacking deliverables on October 11, 2001. In response to BCI's response to this letter, the Commission sent a letter on December 4, 2001 to address remaining specific issues regarding subtasks/deliverables. The issue of the pilot scale results and the ability to continue testing at Collins Pine with the generated “simulated” lignin was discussed at length with DOE/NREL and the project team at a December 20, 2001 CPR meeting at the Energy Commission.

Based on a review of the documentation submitted, we believe that BCI has still not adequately responded to the issues that remain:

- 1) Lack of fundamental data associated with ethanol process validation activity. Examples of the missing fundamental information include material and energy balance data for all process and utility streams, process flow diagrams, sized equipment specification, and cost information.
- 2) Ability of the electricity generation side of the facility to use the “simulated” lignin from the ethanol generation side as a fuel.

These remaining issues posed a serious question about the continuation of this contract. The Commission Contract Manager agreed and recommended to the Commission's Research and Development Policy Committee that the contract be terminated. The recommendation to terminate the contract was heard and approved by the Policy Committee on March 20, 2003.

## Evaporative Cooling of Geothermal Power Plants with Recycled Water

**Contract #:** PIR-00J-002

**Contractor:** Mammoth Pacific LP

**Contract Amount:** \$1,000,000

**Match Amount:** \$4,571,678

**Contractor Project Manager:** Robert Sullivan (760) 934-4893

**Commission Contract Manager:** Pablo Gutierrez (916) 654-4663

**Status:** Cancelled

### Project Description:

The purpose of this project was to increase power production of the combined geothermal power plants in the Mammoth Pacific Limited Partnership (MPLP) by up to 10 megawatts electric (MWe) during the summer months. This would 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 included the evaluation of three different evaporative cooling technologies and the evaluation of two different sources of water. The three evaporative cooling technologies that were tested are:

- 1) Swamp cooler technology utilizing a thick eight-inch thick honeycombed material.
- 2) Wetted pad technology utilizes a two-inch thick honeycombed material.
- 3) Fogger nozzles and no filter media.

Phase 2 consisted of using geothermal fluid as a source of evaporative cooling during the summer months.

### This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by enhancing power generation and improving geothermal power plant efficiency.
- Improving electricity reliability/quality/sufficiency of California's electrical system by providing up to 10 MWe of power during the summer months.

### Proposed Outcomes:

1. For Phase 1, evaluate of three evaporative cooling technologies to determine their effectiveness in increasing power production during the summer months. These technologies will include:
  - A. Swamp Pad Cooler.
  - B. Spray Bars with Wetted Pads.
  - C. Fogger Nozzle.
2. For Phase 2, perform an engineering analysis and the construction, testing of a geothermal fluid conveyance system.

### Actual Outcomes:

1. For Phase 1, resulted in an evaluation of three evaporative cooling technologies to determine their effectiveness in increasing power production during the summer months. These technologies included:
  - A. Swamp Pad Cooler.
  - B. Spray Bars with Wetted Pads.
  - C. Fogger Nozzle.

2. For Phase 2, performed an engineering analysis and the construction, testing of a geothermal fluid conveyance system. Financial considerations including the costs of geothermal fluid chemical treatment, operation and maintenance costs, construction, project financing, capital costs, etc. A permanent chemical treatment system was proposed for construction to supply reclaimed geothermal fluid during the summer months for the G1/G2/G3 evaporative cooling system.

**Project Status:**

This project has been cancelled.

There were several contributing factors regarding suspension of the planned work. The primary factor was that MPLP's facilities are made up of three separate power plants that are similar in design but with significant differences. These differences are important when viewed in relation to the evaporative cooling needs. The project focused on the G1 facility initially because of the relatively small size of the air condensers and the fact that variable frequency drives (VFD's) are available to control air condenser fan horsepower. The G2 and G3 facilities have significantly larger air condensers and do not have VFD's installed. These differences made completing this project much more time consuming and complex than originally contemplated and MPLP asked to be relieved of the responsibility for continuing the project with the G2 and G3 facilities. The Commission agreed with this request and cancelled the remainder of the project. However, there is a successful evaporative cooling system operating on the G1 power plant resulting in up to 2 MWe of increased power production during the hot summer days.

A report was produced November 20, 2001 by the Department of Energy's National Renewable Energy Laboratory: *Report on Measurements of the Evaporative Pre-cooling System at Mammoth Lakes Power Plant* by C. Kutscher and K. Gawlik.

## Strategic Value Analysis: GIS Development

**Contract #:** 500-00-030

**Contractor:** California Department of Forestry

**Contract Amount:** \$280,000

**Contractor Project Manager:** Dean Cromwell (916) 445-4302

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Completed

### Project Description:

The PIER Renewables area is investigating the ability of renewable resources to help make California's electricity system more reliable, affordable, diverse and cleaner. Part of that effort involves assessing the types and magnitudes of problems that may be encountered in the State's electricity system in the future. Another part of that effort involves assessing the amounts, locations and characteristics of renewable resources that could possibly be used to help resolve the identified electricity system problems. Due to the large amount of data and complex nature of the issues being addressed, the assessments will be conducted using geographical information systems. The purpose of this contract is to build off of an existing geographical information system developed and operated by the California Department of Forestry (CDF) to help conduct the assessments. To accomplish this goal, CDF will do the following:

- Analyze existing spatial information related to energy use and environmental and demographic characteristics of sub-regions within the State.
- Create required data layers on available renewable energy resources.
- Use data on problem areas within California's electricity system developed by another contract (500-00-031, with McNeil Technologies).

As a result, this contract will identify areas where renewable distributed generation (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:

1. Collect data sets necessary to create thematic layers on renewable energy resources within California including 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.
2. 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 public benefits that extend beyond the beneficial impacts to the electricity system.
3. 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.

4. 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.
5. 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 other public benefits.

**Actual Outcomes:**

Technical and economic resource assessments were provided for the wind, geothermal and solar technologies. Performance characteristics were prepared for various distributed generation technologies.

After passage of the State's Renewable Portfolio Standard (RPS) and the Energy Action Plan goals for renewables, the PIER Renewables group was asked to have the work on this project help identify impacts to the transmission system and the ability to accelerate RPS goals. Consequently, this meant an additional workload. However, the contractor has provided major work products on the needed GIS model and mapping efforts. To meet RPS requirements, this contract has now been superseded by a new contract 500-04-004 with CDF.

**Project Status:**

This project has been completed. A final report will be published spring 2005.

## 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

**Status:** Completed

### Project Description:

California has a tremendous amount of biomass resources. The State generates over 70 million bone dry tons of biomass residues every year. However, less than six-million tons per year are used to help meet the State's electricity needs. Among the barriers to increased use of biomass residues for energy purposes are the relatively high cost of biomass generated electricity, and its perception as having higher air emissions than other renewable or natural gas alternatives. The purpose of this project is to develop an innovative gasification technology that can be retrofitted to existing biomass combustion facilities to help lower emissions while also enabling use of lower-cost biomass fuels. The technology, Close-Coupled Gasification (CCG), represents a synergistic combination of direct combustion, biomass/waste gasification, and GE-EER's emission control approaches.

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 nitrogen oxides (NO<sub>x</sub>) 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).

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.

### This project supports the PIER Program objective of:

- Improving the environmental and public health risks/costs of California's electricity by developing a lower-cost method for existing, biomass power plants to control NO<sub>x</sub> and other pollutant emissions.

### Proposed Outcomes:

1. Design and develop 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<sub>x</sub> control in California biomass boilers.
2. Produce 10-30 percent of gaseous fuel (by heat input) for a 25 megawatt (MW) biomass boiler.

3. Reduce NO<sub>x</sub> emissions up to 65 percent in basic reburning and 90 percent in advanced reburning (AR) complying with all other California emissions standards.
4. Reduce NO<sub>x</sub> control costs by at least 20 percent compared to the costs of existing NO<sub>x</sub> control methods used by biomass boilers owned by Wheelabrator Shasta/Hudson Energy Company, Woodland Biomass, and Wadham Energy.

**Actual Outcomes:**

1. Designed and developed 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<sub>x</sub> control in California biomass boilers.
2. Produced 10-30 percent of gaseous fuel (by heat input) for a 25 megawatt (MW) biomass boiler.
3. Reduced NO<sub>x</sub> emissions up to 65 percent in basic reburning and 90 percent in advanced reburning (AR) complying with all other California emissions standards.
4. Reduced NO<sub>x</sub> control costs by at least 20 percent compared to the costs of existing NO<sub>x</sub> control methods used by biomass boilers owned by Wheelabrator Shasta/Hudson Energy Company, Woodland Biomass, and Wadham Energy.

**Project Status:**

- The project and final report have been completed and will be published.
- Achieved all the proposed outcomes of the project.
- The Contractor has proposed to move to Phase II of the project.

## Wind Turbine Company EMD Turbines

**Contract #:** 500-00-019

**Contractor:** Wind Turbine Co.

**Subcontractors:** Garrad Hassan Ltd. : Windward Engineering : Hamilton Sunstrand : ATK Thiokol Propulsion : Commercial Casting Company : Navigant Consulting, Inc.

**Contract Amount:** \$1,300,000

**Contractor Project Manager:** Kenneth Deering (425) 637-1470

**Commission Contract Manager:** Mike Kane (916) 654-7119

**Status:** Completed

### Project Description:

Under Phase I, 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 purpose of this project was 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, e.g., fossil fuel and natural gas. The objectives were to develop and to test a lower-cost grid-connected 500kW commercially-viable Engineering and Manufacturing Development (EMD) wind turbine scalable to 750kW at a California site. The machine was to be suited for both grid-connected and for standalone applications in combination with other generation and energy storage options. The turbine demonstration was located at the Fairmont wind site in Southern California.

The 250kW prototype proof-of-concept (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, the 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).

### 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.

### Proposed outcomes:

1. Bring to market readiness a commercially viable and competitive turbine.
2. Provide electrical power to the California grid.
3. Produce a "free" and "clean" fuel generation system to provide reliable and cost competitive energy alternatives to consumers.
4. Advance turbine design and manufacturing with an innovative lightweight and flexible design that reduces structural loads and improves turbine reliability and service life.
5. Put California back into the spotlight as a leader in wind energy resources.

### 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 to determine cause of the incident. Based on the NREL findings, control and protection software has been upgraded to prevent additional strikes. The EMD was refitted with a pair of off-the-shelf blades and resumed operation in March 2003. In May 2003, EMD suffered a failure of the main rotor shaft, rendering the turbine inoperable. For safety reasons the turbine was dismantled. The Commission issued a partial stop work order to allow the contractor to determine the reason for the failure. In conjunction with NREL, an independent failure analysis was conducted. The initial findings indicated the failure to be related to the previous blade strike event. The analysis did not find any inherent flaws in the two-bladed downwind technology, but suggested that further load analysis be performed on the design. The Commission authorized WTC to complete the load analysis on the revised design of the EMD called the EMD-2.

The Commission conducted an independent technical due diligence of the technology. Separate from the technical analysis conducted by NREL, the Commission examined WTC's organization and operation structure. Given the findings of the loads analyses conducted by NREL and the separate due diligence report, the Commission project team determined that WTC would need to secure additional match funding and partners to return the project to viability. WTC was unable to find sufficient match funding and the project was closed out in June, 2004.

## **REN Projects Completed in 2003**

## Collins Pine Co. BCI Cogeneration Project

**Contract #:** 500-98-043

**Contractor:** Collins Pine Company

**Subcontractors:** BC International Corporation : National Renewable Energy Laboratory (NREL) : Plumas Corporation : Kেমestrie : 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

**Status:** Cancelled

### 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 objectives of:

- Improving energy cost/value.
- Improving the environment, public health and safety.
- Improving electricity reliability, quality and sufficiency.
- Address important RD&D gaps.
- Providing greater choices for CA consumers.
- Connecting to near-term market applications.

### Proposed Outcomes:

1. Improve 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.
2. Maximize market/economy connection by providing positive impacts to California local economies by the creation of new jobs and new tax revenues in a rural area.
3. Determine whether the ethanol facility can produce up to 20 million gallons per year of ethanol from softwood feedstock using BC International (BCI) technologies.
4. 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.

5. Identify at least one co-product, other than lignin or ethanol, which can be produced by the ethanol facility.
6. Reduce the cost of electricity production at the Collins Pine biomass power plant by at least 1.5 cents/kWh.
7. 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.

**Actual Outcomes:**

In October of 1998, the Commission signed the Contract with Collins Pine Company to fund a research, development, and demonstration project under the Public Interest Energy Research (PIER) program. The total PIER budget to this contract is \$1,148,961. The match funding of \$375,274 is provided by DOE/NREL. The project was originally scheduled to be completed by December 2000. The project completion schedule was extended to December 31, 2001.

The Energy Commission (Commission) issued a stop work order to this contract on September 19, 2001 due to lack of deliverables due from subcontractors, in particular BC International (BCI). The Commission sent a stop work order following up letter that included a list of lacked deliverables on October 11, 2001. To respond BCI's comments provided to the stop work order following up letter, the Commission sent a response letter on December 4, 2001 to address remaining specific issues regarding subtasks/deliverables. The issue of the pilot scale results and the ability to continue testing at Collins Pine with the generated “simulated” lignin was discussed at length with DOE/NREL and the project team at a December 20, 2001 CPR meeting at the Energy Commission.

Based on a review of the documentation submitted, we believe that BCI has still not adequately responded to the issues on the project. The two remaining outstanding issues with this project include:

1. Lack of fundamental data associated with ethanol process validation activity. Examples of the missing fundamental information include material and energy balance data for all process and utility streams, process flow diagrams, sized equipment specification, and cost information.
2. Ability of the electricity generation side of the facility to use the “simulated” lignin from the ethanol generation side as a fuel.

The remaining issues pose a serious question on the continuation of this contract. The Commission Contract Manager agreed and recommended to the Commission's Research and Development Policy Committee that the contract be terminated. The recommendation to terminate the contract was heard and approved by the Policy Committee on March 20, 2003.

**Project Status:**

The contract was terminated on April 14, 2003.

## 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

**Status:** Completed

### 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.
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 have 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. Recovering energy from a geothermal reservoir requires that mass be withdrawn from it. The basic components of the resource at The Geysers are its reserves of steam and immobile, or in-situ water. Under exploitation the vapor-dominated field can be depleted of water in some places, to form a dry or superheated zone. There is then a recharge of steam from boiling of the immobile water. Even though the steam is the principal recovery fluid, by mass the immobile water is a much larger component of the reservoir fluid than the steam. Therefore it is important to quantify the immobile water in the reservoir. Knowing the immobile water saturation will provide better understanding of the fluid storage capacities of the rocks. This is valuable for estimating the performance of a geothermal reservoir and its capacity for further exploitation.

### 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.
- 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 water reinjection, notably from the Lake County Sanitation District pipeline, began to renew the resource. An additional large-scale reinjection pipeline (the Santa Rosa pipeline) came on-line in late 2003. Knowing where saturation occurs now and where it occurred in the past is expected to improve managers' ability to make strategic decisions about operations, development and management, by aiding in understanding where exploitation has led to dry-out and where immobile water mass might be, or might have been, rejuvenated by injection. This can help in designing locations and timing of large and small scale injection projects. Presenting results of the project in meetings and journals will benefit the technical research community and provide a conduit for practical application.

**Actual Outcomes:**

Historical records of well pressure, temperature flow rate and enthalpy from wells distributed over The Geysers area, operating in different time periods and in 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. Data analysis used a model developed by the Stanford team to infer the historical in-situ water saturation at The Geysers. The researchers were able to show that well performance data history can be used to infer in-situ water saturation. Using the data from the wells and the model, the team determined the stable initial and dry-out subsurface temperatures for individual wells in the field, and computed the in-situ water saturation in the vicinity of those wells. By using wells that started operation over a range of time, the team inferred the evolution of saturated conditions in the reservoir. They also were able to determine the variation in saturation from one area to another within the reservoir and to identify superheated areas. This work involved analyzing the data for over 500 wells for which records are available. This work identified 177 wells that had become superheated and 147 wells that are inferred not to have reached superheat. The remaining 179 wells in the database have data that is too sparse to observe temperature-pressure trends. Most of the superheated wells are in the northwest portions of the field. The saturated (i.e., not superheated) wells are mostly in the southeast positions of the field.

The team also investigated the possible effect of increase in the calculated saturation values due to artificial reinjection. Reinjection influence was simulated using TOUGH2. Simulations varied the flow rate and location of reinjection with respect to nearby production wells. It was found that higher injection flow rates and proximity to producing wells increases the apparent saturation values. This influence may explain the apparently higher in-situ water saturation in the Southwest zone of The Geysers field. It is likely therefore that optimizing injection rate, location, and possibly temperature can be used to increase local apparent saturations in the vicinity of a producing well.

To facilitate technology transfer, make the results of the work available to the operating companies, and make the methods known to the research community, several papers were prepared and presented in meetings and journals. Practical application of the results of this work will need to be made by the field operators. Electronic and hard copies of these were part of project submittals and are included in the Commission's files. The Final Report for the project will be available through the Energy Commission's website and in the Commission library.

**Project Status:**

The project has been completed.

## Renewable Technology Strategic Information

**Contract #:** 500-02-028 **Project #:** 15

**Contractor:** Electric Power Research Institute (EPRI)

**Project Amount:** \$45,000

**Contractor Project Manager:** Chuck McGowin (650) 855-2445

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

**Status:** Completed

### Project Description:

Renewable energy technology development and deployment are proceeding rapidly throughout the world as power agencies and project developers respond to the growing demand for new green power sources and technology developers continue to improve the efficiency and cost performance of renewable technologies. As a result, renewable technology status, performance, cost, installed capacity, markets, and other characteristics continue to change rapidly. This project maintains an up-to-date and objective strategic assessment of renewable technology for use in strategic planning and decision making.

### This project supports the PIER Program objective of:

- Providing greater choices for California consumers by supporting compilation and updates of renewable technology development and deployment information.

### Proposed Outcome:

1. A status report and regularly issued updates that describe renewable technology status including: performance, cost, installed capacity, and markets.

### Actual Outcome:

7. Technical Report, Renewable Energy Technical Assessment Guide (TAG-RE), EPRI Product # 1004938.

### Project Status:

The project has been completed.

## **REN Projects Completed in 2002**

## **Application of Small Modular Biopower System for Power Generation from Forest Residue**

**Contract #:** 500-99-029

**Contractor:** Community Power Corporation

**Subcontractors:** Shell International Renewables : National Renewable Energy Laboratory (NREL)

**Contract Amount:** \$645,827

**Match Amount:** \$609,695

**Contractor Project Manager:** Robb Walt (303) 933-3135

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Completed

### **Project Description:**

The purpose of this project is to design, develop and demonstrate a stand-alone, small modular biopower (SMB) system rated at 12.5 kW for a distributed generation application providing both electricity and heat using two different types of forest residue.

This project is Phase II of an SMB initiative co-funded by the National Renewable Energy Laboratory (NREL)/US Department of Energy (US DOE). In this Phase, the Contractor shall design, fabricate and test two SMB systems namely NREL SMB and PIER SMB. The NREL SMB project is funded by NREL/US DOE and Shell International Renewables, Ltd. for a rural electrification project in the Philippines. The PIER SMB is funded by PIER and co-funded by NREL/US DOE. The Contractor shall design, fabricate and test PIER SMB, based on lessons learned in NREL SMB, for combined power and heat application at Tsemeta Forest Regeneration Complex, Hoopa, California. Phase I of the SMB initiative is a feasibility stage, completed and funded mainly by NREL/US DOE and not PIER funds.

### **This project supports the PIER Program objectives of:**

- Improving environmental and public health costs/risk of California's electricity by mitigating air quality impacts and reducing environmental risks. If successful, this technology will provide beneficial means of forest residue disposal, reduce wildfires, and reduce air pollution from in-forest burning of slash.
- Improving the reliability/quality of California's electricity by removing barriers to distributed generation technology.

### **Proposed Outcomes:**

#### 1. Proposed Technical Outcomes:

The overall technical objective of this project is to develop and demonstrate a 12.5 kW small modular biopower system in a displaced retail, combined heat and power application, and collect the data needed to develop the scale-up path to a family of commercially viable systems in California.

The specific technical objectives are:

- Provide up to 12.5 kilowatt electric (kWe) and 20 kilowatt thermal (kWt) power to the proposed on-site load.
- Provide 220 volts, 3 phase power for the proposed load in parallel with the grid.
- Operate with no more than one operator.
- Provide 12.5 kWe power using two of the following feedstocks: Oak, Alder, Madrone and/or Douglass Fir.

- Incorporate system improvements based upon data collected during operation.
  - Translate operating performance of a 12 kW system into clear technical requirements for development of a family of small modular biopower systems between 12 kW and 500 kW.
  - Achieve combined heat and power efficiencies of greater than 60 percent. Electrical efficiency to be no less than 18,000 Btu/kWh (higher heating value (HHV)).
  - At peak power of 12.5 kW<sub>e</sub>, the small modular biomass (SMB) system will meet or exceed California's emission standards for a 4 cylinder automobile internal combustion engine. Nitrogen oxides (NO<sub>x</sub>) emissions of engine no greater than 1,500 ppm (at full load, 3% O<sub>2</sub>). Particulate matter (PM) emissions no greater than 5 ppm.
2. Proposed Economic Outcomes: The overall economic objective of this project is to achieve competitive financial performance for a family of distributed generation applications of the SMB system, both on-grid and off-grid.

The specific, cost objectives for the minimum and maximum size ranges are shown below. This assumes the global sales of SMB system of 1000 units a year.

- 500 kW (grid-connected).
  - Capital cost of \$600 per kW.
  - Electricity cost of less than 7 cents per kWh.
  - Heat cost less than \$0.70 per therm.
- 12 kW (grid-connected and off-grid).
  - Capital cost of \$1,000 per kW.
  - Electricity cost of less than 15 cents per kWh.
  - Heat cost less than \$1.20 per therm.

**Actual Outcomes:**

1. The project kick-off meeting was held at Hoopa Valley on November 1, 2000.
  - Task 2.1 Develop, Install and Operate NREL-SMB:
    - The work related to shakedown testing of the first small modular biopower system developed under Phase 2 contract with NREL was completed. Endurance runs at CPC generated 1 MWh of electricity and 145 hours of operation. The unit was shipped to the Philippines in February 2001, and was installed and commissioned on April 2, 2001 in Alaminos, Philippines for the field endurance testing.
  - Task 2.4 Build/test PIER-SMB (Test Bed):  
Preliminary layout of the SMB system at the Hoopa Forest Regeneration Complex was completed. The system was installed. Testing and analysis was performed.
  - Task 2.9 Deploy PIER-SMB/CHP:  
Modifications were completed to test the system for combined heat and power. A heat exchanger was fabricated and installed on the PIER-SMB to collect waste heat and deliver hot water to the greenhouse.
2. The PIER-SMB was performance tested. In addition, the system was grid connected and was tested in the combined heat and power (CHP) mode. Following are the project outcomes:
  - System was operated in CHP mode at 12.5 kW<sub>e</sub> and 20 kW<sub>th</sub> delivered to the hot water system at Hoopa.
  - More than 80 operational problems were identified and improvements implemented to the gasifier, cooling and cleanup system, dryer subsystem, and char subsystem during the course of the project.

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- The SMB demonstrated a combined heat and power efficiency of 60%.
- NO<sub>x</sub> emissions from the engine were typically less than 150 ppm, and hydrocarbon emissions were negligible.

**Project Status:**

Project was completed early on June 15, 2002.

## Design & Optimization of a Solar Fired 2E Absorption Chiller

**Contract #:** 500-97-035

**Contractor:** Bergquam Energy Systems

**Subcontractors:** Richard Christensen, Ohio State University : Sun Utility Network : Thermal Energy Systems Specialists : Instructional Systems.

**Contract Amount:** \$150,000

**Match Amount:** \$150,000

**Contractor Project Manager:** Jim Bergquam (916) 383-9425

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Completed

### Project Description:

This purpose of this project was to optimize the performance of a solar-fired, double-effect absorption chiller that can be used for space cooling of small to medium-sized commercial buildings. In addition, the project will modify and test the solar-fired chiller to determine generator configuration and operating conditions that maximize chiller and system performance.

### This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing electrical consumption during peak demand created by cooling commercial buildings.
- Improving the energy cost/value of California's electricity by replacing packaged, compressor-based air conditioning systems with a lower-cost solar absorption system.
- Improving the environment and public health of California's electricity by replacing CFCs in compression air conditioners with environmentally safe lithium bromide and water as the working fluid in a solar-driven absorption chiller.

### Proposed Outcome:

1. A high-efficiency, double-effect absorption chiller that is optimized for coefficient of performance (COP), cooling capacity and operating temperature.
  - Solar collectors will drive the chiller.
  - The chiller will have a coefficient-of-performance (COP) in the range of 1.2 to 1.4, when the first stage generator is operated at high temperature (approximately 300 degrees F).
  - The chiller will have a COP in the range of 1.1 to 1.2, when the first stage generator is operated at low temperature (below 250 degrees F).

### Actual Outcomes:

1. Thermodynamic computer models of first stage generator were designed and updated to predict and evaluate performance of the solar-fired double effect absorption chiller.
2. The testing to determine the heat transfer co-efficient of generator tubes was completed.
3. A device was built called the Twister which twists the stainless steel strips for greater heat transfer in the generator. With the inserts, the heat transfer coefficient is increased by a factor of 2 to 3.
4. The chiller was tested with the first stage generator at low temperature as well as high temperature and was demonstrated at the specified performance levels.

### Project Status:

The project has been completed.

## Development of an Extended Logging Tool for Geothermal Exploration and Field Development

**Contract #:** 500-97-034

**Contractor:** Electromagnetic Instruments

**Subcontractors:** Lawrence Livermore National Laboratory

**Contract Amount:** \$1,380,709

**Match Amount:** \$1,407,953

**Contractor Project Manager:** Michael Wilt (510) 232-7997

**Commission Contract Manager:** Gail Wiggett (916) 653-7551

**Status:** Completed

### Project Description:

The purpose of this project was to design, manufacture and field test an extended induction logging device for geothermal applications in California. During the 3 year project, hardware and software for a high-temperature and pressure-tolerant logging tool were to be developed and tested in several field trials in California, and if possible, internationally.

This device provides a three dimensional image of the formation resistivity in the vicinity of a geothermal borehole. It can identify electrically conductive regions associated with high temperature fluids and map through-going fractures, which play a crucial role in fluid production in both geothermal and petroleum reservoirs.

The decline of power generation at the Geysers from a peak capacity of nearly 2000 MW to current production of less than 1000 MW emphasizes the need for improved reservoir management. In addition, the cost of geothermal development in new or existing fields is extremely high. The contributions that a subsurface imaging tool like GeoBILT can make to the geothermal industry are important, because improved understanding of a reservoir's fracture systems can help improve the targeting of new geothermal well sites and aid in mapping fractures and permeable zones for production or injection. Other geophysical tools are available, but the Geo-BILT tool is unique in its combined ability to produce 3-dimensional imaging and models at a distance from a borehole AND to operate under rigorous geothermal conditions. Existing commercially available instruments cannot do this.

### This project supports the PIER Program objectives of:

- Improving the reliability and quality of California's electricity by providing a tool that can provide improved acquisition of key subsurface data, facilitating better understanding of reservoir fracture systems and formation resistivities, and leading potentially to more effective reservoir management by optimizing field production and coordinating recharge activities.
- Improving the energy cost and value of California's electricity by developing and making available new logging services and enhancing the efficiency of geothermal energy exploration.
- Improving the environmental and public health costs and risks of California's electricity by aiding in developing an environmentally benign renewable energy source.

### Proposed Outcomes:

1. Design and construction of instrumentation and accompanying interpretive software that will provide technological solutions to several important problems in geothermal exploration and field development.

2. Provide an instrument that will improve reservoir definition and fracture mapping in geothermal boreholes. This will better define drilling targets and reduce the number of boreholes required to produce adequate steam for power generation.

**Actual Outcomes:**

1. Successful field tests were conducted at several non-geothermal sites that have known geologic conditions, in order to test the instrument's ability to detect permeability and saturation differences. Field tests under geothermal conditions were conducted as planned at Dixie Valley, Nevada.
2. The first Dixie Valley field test successfully demonstrated that the instrument can operate in high temperatures. This demonstration was a major goal of the project. Significant amounts of valuable data were collected during this test. A second test in Dixie Valley successfully illustrated the instrument's ability to collect 3-dimensional data around the borehole and to image non-horizontal geological structures.
3. GeoBILT holds significant promise for commercialization within the petroleum industry, and remains, at present, the only logging tool available that can operate under rigorous geothermal conditions. There is considerable industry interest in GeoBILT and its further development. Additional new applications of the technology are also being explored, including its use in research studies of seismic zones. Further indication of GeoBILT's perceived potential is given by the acquisition of Electromagnetic Instruments, Inc. by Schlumberger, the world's largest purveyor of geophysical services.
4. EMI personnel made a final presentation of the results at the Energy Commission on 6 December 2002, a copy of which is available through the Commission website. The final report also is available electronically.

**Project Status:**

The project has been completed. As with many research and development projects, a number of difficulties were encountered that led to delays in the project's schedule. As a result, it was not possible to complete the international geothermal field tests that had been projected as possible tasks late in the contract duration.

## Hybrid Solar-Fossil Thermophotovoltaics

**Contract #:** 500-97-048

**Contractor:** EDTEK

**Subcontractors:** Brookhaven National Laboratory : Power Management Systems, Inc. : The Charters Group, Inc. : NML Partnership : Pacific Financial Group

**Contract Amount:** \$867,945

**Match Amount:** \$1,917,107

**Contractor Project Manager:** William Horne (253) 395-8084

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Completed

### Project Description:

The purpose of this project is for EDTEK, Inc. to design, fabricate and test a modular, hybrid solar/fossil-fueled thermophotovoltaic (SFTPV) system that can produce electricity and process hot water 24 hours per day with a recovery efficiency of about 83 percent. In this system, highly concentrated sunlight is directed into a cavity where the surrounding walls are heated to incandescence, the state where visible light is emitted from a hot object. A natural gas flame is also directed into the cavity to heat its walls and excite the PV cells, as does the concentrated sunlight.

### This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing a new distributed generation technology.
- Improving the environmental and public health costs/risks of California's electricity through partial use of solar energy, a renewable and non-polluting energy source.

### Proposed Outcomes:

Develop, manufacture and demonstrate a pre-production hybrid prototype SFTPV cogeneration power system that can produce economically competitive electric power and thermal energy on a 24-hour basis. The SFTPV power system will convert sunlight to electricity with 25 percent overall efficiency and natural gas to electricity at an overall efficiency of 20 percent while producing process grade hot water at a recovery efficiency of 83 percent.

### Actual Outcomes:

The contractor has worked with Cornell University, the University of Houston, and NREL to use ion beam lithography process and e-beam lithography to prepare stencils for the pre-filters.

Additionally:

1. The gallium antimony (GaSb) PV cells were assembled into arrays for the test unit and final interconnections were completed.
2. The prisms were fabricated and the reflecting coatings were applied. A dish mounting and tracking system was designed.
3. A test of hydraulic tacking mechanism has been successfully completed.
4. The solar concentrator dishes were fabricated, and the smoothing, reflective and glass protection coatings were applied.
5. The SFTPV system was tested as required per specifications.

### Project Status:

The project has been completed.

## Natural Gas Cofiring in Biomass Fueled Boilers

**Contract #:** 500-97-040

**Contractor:** Gas Research Institute

**Subcontractors:** ARCADIS Geraghty & Miller International : COEN Company, Inc. : Burney Mountain Power : Fairhaven Power Company

**Contract Amount:** \$655,702

**Match Amount:** \$731,784

**Contractor Project Manager:** Isaac Chan (773) 399-5411

**Commission Contract Manager:** Prab Sethi (916) 654-4509

**Status:** Completed

### Project Description:

The purpose of this project is to develop and retrofit low NO<sub>x</sub> gas cofire technology on two biomass fired industrial power boilers at Burney Mountain Power and Fairhaven Power. With biomass, the high fuel moisture level and high fuel quality variability reduce electric competitiveness and increase environmental compliance costs. By firing small amounts of gas, approximately 10 percent of total heat input, operators can control the combustion process and avoid the usual problems that accompany combustion of wet biomass. Cofire offers an independently controlled combustion zone with higher temperatures, resulting in faster load response, better CO and opacity burnout, reduces carbon in the ash, and faster, cleaner startup. These benefits are essential for biomass to compete in the volatile deregulated power market that requires greater responsiveness than is now possible.

In this project, GTI will subcontract the low NO<sub>x</sub> burner development to the cofire burner developer, Coen. The low NO<sub>x</sub> burner will retain the high-pressure drop feature used earlier, but employs segmented fuel gas/ combustion air zones and possibly induces an enhanced draw of (combustion) air using the properties of the (fuel) gas stream. The prototype burner will be installed in two northern California biomass power plants: Burney Mountain Power and Fairhaven Power. At Burney, cofire will allow recovery of lost derate and allow peak revenue load dispatch to effectively meet changing power demand. At Fairhaven, cofire will recover lost derate and allow compliance with CO and NO<sub>x</sub> regulations.

### This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing a method for improving the economics of grid-connected, distributed electricity generating biomass facilities.
- Improving environmental and public health costs/risk of California's electricity by mitigating air quality impacts from biomass combustion by cofiring biomass with natural gas within an independently controlled combustion zone with high-temperature, turbulent mixing. The low NO<sub>x</sub> feature is unique to California, and this demonstration should facilitate cofire permitting at other biomass facilities.
- Impacting local and state economies by preserving employment opportunities in rural areas where these biomass facilities are typically located.

### Proposed Technical Outcomes:

1. Develop a low NO<sub>x</sub> cofire burner for application to biomass fueled boilers.
2. Apply the low NO<sub>x</sub> cofire burner to increase the load following capability and turndown for Burney Mountain Power.

3. Apply the low NO<sub>x</sub> cofire burner to reduce CO emissions and recover lost derate with wet wood at Fairhaven Power.

**Proposed Economic/Cost Outcomes:**

1. Apply cofiring at Burney Mountain Power to capture high revenue power peaks and avoid low revenue periods to allow operation in the deregulated power market and reduce the break-even power price.
2. Apply cofiring at Fairhaven Power to recover lost derate with wet wood and accrue incremental power sales revenue over the differential fuel price.

**Actual Outcomes:**

1. Burner system installation on the 10 MW-boiler at Burney Mountain Power plant in Burney, California was completed in March 2000. A new gas pipeline from the Pacific Gas & Electric main transmission line to the boiler was installed. Burner start up and system testing and performance optimization was performed during 2001 and 2002.
2. Required modifications to reduce NO<sub>x</sub> emissions and performance optimization of Fairhaven Power plant in Eureka, California were incorporated during a scheduled plant outage.

**Project Status:**

The project has been completed.

## PowerGuard California Manufacturing

**Contract #:** 500-97-049

**Contractor:** Powerlight Corporation

**Subcontractors:** Pulse Energy Systems : Trace Technologies, Inc. : Colorado State University : Augustyn + Company : T. Clear Engineering : Feldman, Waldman and Klein : Solarex : Ananda Power Technologies

**Contract Amount:** \$958,991

**Match Amount:** \$1,994,421

**Contractor Project Manager:** Thomas Dinwoodie (510) 540-0550

**Commission Contract Manager:** Joe McCabe (916) 654-4412

**Status:** Completed

### Project Description:

The purpose of this project is to expand grid-connected markets for PowerGuard® systems by reducing component and system manufacturing costs, enhancing system reliability, and obtaining specific certifications. PowerGuard® is a rooftop photovoltaic (PV) system providing electrical power. Furthermore, this project established a new California manufacturing facility, using the automated and semi-automated fabrication innovations developed under this contract.

### This project supports the PIER Program objectives of:

- Improving the reliability of California's electricity system by developing a renewable, distributed-energy technology.
- Improving the environmental and public health costs/risks of California's electricity by deploying a renewable energy source which does not emit NO<sub>x</sub> (nitrous oxides), SO<sub>x</sub> (sulfur oxides), and CO<sub>2</sub> (carbon dioxide) when generating electricity.
- Positively impacting California's economy by creating new manufacturing jobs.

### Proposed Outcomes:

1. Reduce component and system manufacturing costs.
2. Enhance system reliability.
3. Obtain specific certifications.

### Actual Outcomes:

Over the course of this contract, many improvements were made to the PowerGuard product and manufacturing process. These enhancements have reduced the cost of PowerGuard installations, improved the quality and reliability of the PowerGuard product, added features to PowerGuard systems, and provided paths to new markets. A summary of the major accomplishments is listed below:

1. Production rate rose from 200 tiles per 8-hour shift to more than 500 tiles per 8-hour shift.
2. System cost of PowerGuard was reduced by 38%.
3. Balance of System cost was reduced by 68%.
4. Quality of PowerGuard was improved through the implementation of improved production tools and inspection equipment.
5. A sloped PowerGuard tile design was developed.
6. A comprehensive warranty was developed for PowerGuard systems.
7. Extensive wind tunnel testing was used to refine the PowerGuard tile design and to develop installation criteria for a wide variety of conditions and geographical locations.

8. Integrated design software was developed using an off-the-shelf platform to simplify the design of PowerGuard systems by Value-Added Resellers.
9. Seventeen PowerGuard tiles, using PV modules from different manufacturers, have been listed by UL.
10. PowerGuard accessories such as curbs, T-harnesses, and standardized combiner boxes have been submitted to UL for listing.
11. PowerLight has applied for certification of PowerGuard by the International Conference of Building Officials (ICBO).
12. All required tests have been completed to allow the use of the CE mark, allowing the sale of PowerGuard into the European Union.
13. All test required by the International Electrotechnical Commission (IEC) and Institute of Electrical and Electronics Engineers (IEEE) standards have been passed.
14. Modular and standardized PowerGuard system packages were developed to reduce the cost of small systems.
15. An installation manual and training program was produced for installing PowerGuard systems.
16. Clean-up and waste management processes have been improved leading to the recycling of almost all waste products.
17. PowerLight has ensured that the production of PowerGuard conforms to National Environmental Policy Act (NEPA), Occupational Safety and Health Administration (OSHA), and all other applicable federal and state regulations.

**Project Status:**

This project is completed, under budget, on time and is providing royalties to the State of California. Many accomplishments were achieved including:

- Increased production rates.
- Reduced system costs.
- Increased product quality.
- UL listings.

## PowerTherm Product Development

**Contract #:** 500-97-046

**Contractor:** Powerlight Corporation

**Subcontractors:** Advanced Thermal Technologies, Inc. : Sealed Air Corp. : Kathabar, Inc. : David Roodvoets

**Contract Amount:** \$542,362

**Match Amount:** \$1,052,361

**Contractor Project Manager:** Thomas Dinwoodie (510) 540-0550

**Commission Contract Manager:** Joe McCabe (916) 654-4412

**Status:** Completed

### Project Description:

This purpose of this project is to test a commercial photovoltaic/rooftop solar energy collector system providing electric power and thermal energy from sunlight. The integration of a solar-thermal component with the Contractor's PowerGuard® photovoltaic system will create a hybrid photovoltaic/thermal (PV/T) system, called PowerTherm™. This technology is suitable for buildings with flat to moderately sloping roofs and will increase the economic value of PV roof-tile systems for commercial building owners by providing them with two ways to lower their energy utility costs: PV-electrical generation and solar hot-water production for on-site use.

The PowerGuard® product was substantially advanced under a product R&D contract with the Commission's Energy Technologies Advancement Program and has been successfully tested in dozens of applications internationally. PowerGuard® incorporates state-of-the-art PV technology with extruded foam backing into roofing tiles. These tiles, or panels, are electrically connected to an inverter that feeds quality AC Power to the building's electrical system at or near peak load demand periods for electricity suppliers. This technology can be integrated into new and re-roofing projects, or readily applied over existing roofs.

### This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity system by developing a distributed-energy technology.
- Improving environmental and public health cost/risks of California's electric system by deploying a renewable energy source that does not emit nitrous oxides, sulfur oxides, and carbon dioxide when generating electricity.

### Proposed Outcomes:

1. Research, develop, and demonstrate a cost-effective PowerTherm™ product for commercial and residential building owners.
2. Improve heat transfer between the PV laminate and solar-thermal absorber by 29 percent.
3. Increase the thermal performance of the overall system by 38 percent.
4. Improve the overall system efficiency by 98 percent over side by side PV and thermal collectors.
5. Achieve a net (thermal-only) system production tile cost of less than \$6 per square foot.
6. Achieve a thermal component payback of less than 5 years in specified markets.

### Actual Outcomes:

1. Identified lucrative target markets for PowerTherm: through extensive market analysis and a thorough assessment of product capabilities, commercial and residential pool heating applications in Hawaii and California were identified as ideal near-term markets for this product.

2. Created initial product concept: by leveraging the successful product development and manufacture of PowerLight's flagship product, PowerGuard©, PowerLight quickly initiated development and testing of its first PV/T product concept.
3. Developed a unique product: through design iteration, materials research, testing, and development of supplier relationships, PowerLight created a unique, high quality product which uses inexpensive flexible thin film technology bonded to commercially available unglazed solar thermal collectors. Each 4'X10' collector will produce approximately 315 kWh of electricity and 2,100 kWh of heat annually for swimming pools in a California climate.
4. Developed advanced manufacturing and fabrication techniques: improvements in the manufacturing process were made by reducing both cost and cycle time. Design and development of unique lamination equipment and materials led to significant progress toward product commercialization.
5. Deployed six successful demonstration systems: these systems were installed and monitored at two sites in California and one in Hawaii for testing and performance verification purposes.
6. Researched applicable certifications needed for commercialization: these included ICBO, IEC and UL certifications. UL conducted a design review of PowerTherm.
7. Developed business and marketing strategies: PowerLight developed a finance packaging plan, identified and built alliances with key industry partners, and developed installation, operation, and maintenance plans for the product.
8. Developed equipment that can be used both for production and further research.
9. Optimized critical manufacturing process parameters: through iterative testing and trial manufacturing runs, these parameters were adjusted in order to achieve high quality product parts.
10. Produced full-sized prototypes for certification and field-testing purposes: demonstration systems were installed to monitor performance and reliability. In addition, a full sized system has been sent to FSEC for evaluation.

**Project Status:**

This project is completed, under budget and on time.

## Renewable Technology Options & Green Power Marketing - Program 84

**Contract #:** 500-00-023 **Project #:** 60-61

**Contractor:** Electric Power Research Institute (EPRI)

**Project amount:** \$45,522

**Match amount:** \$503,463

**Contractor Project Manager:** Chuck McGowin (650) 855-2445

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

**Status:** Completed

### Project Description:

The purpose of these EPRI projects 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.
- 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 EPRIweb-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:**

Project is complete.

## Residential Electric Power Security

**Contract #:** 500-97-047

**Contractor:** Kyocera Solar, Inc.

**Subcontractors:** Southwest Technology Development Institute : New Mexico State University

**Contract Amount:** \$426,343

**Match Amount:** \$994,799

**Contractor Project Manager:** Joel Oatman (480) 443-7732

**Commission Contract Manager:** Joe McCabe (916) 654-4412

**Status:** Completed

### Project Description:

The purpose of this project was to design, assemble, and test a photovoltaic (PV) power system for residential rooftop applications. The project will focus on three aspects of the system:

1. UPG will design, assemble, and test a novel rooftop PV panel attachment and interconnection process.
2. UPG will produce a fully integrated multifunctional dc-ac/ac-dc power collection, conversion, and control unit.
3. Develop an optional low-cost battery unit designed to plug into the Power Unit to provide a dependable supply of energy for critical household loads.

The proposed PV power system will possess features such as low cost, high efficiency, adaptable to a wide range of roof tops, high power quality, and compliance with all NEC, UL, IEEE, and Utility Interconnection Codes and Standards. The developed system is expected to reduce the installed cost of grid connected PV by approximately 34 percent, and improve their reliability by a factor of five.

### This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by increasing reliability over current systems from 10 percent rate of failure to 2 percent rate of failure (a five fold improvement).
- Improving the energy cost/value of California's electricity by optimizing design of residential roof-mounted PV through a system integration approach, increase system modularity to reduce manufacturing costs, and develop standardized hardware and methods for PV/roof attachment to reduce installation costs.

### Proposed Outcomes:

1. Develop an advanced version of the multi-functional rooftop PV power processing system with a number of market driven advanced capabilities which do not exist in any commercially available power processing product.
2. Contractor anticipates reducing materials and installation costs (exclusive of the PV module) by 30 percent.

### Actual Outcomes:

1. Design revisions of the PV array.
2. Submission of PV Array for UL review.
3. Installation of a production version of the PV Array.
4. Submission of Power Unit CAM files of revised printed circuit boards to vendors.
5. Design revisions of Power Unit electro-mechanical system.
6. Submission of Power Unit for UL review.
7. Design revisions of Energy Storage Unit.

8. Submission of Energy Storage Unit for UL review.
9. Testing of Energy Storage Unit.
10. UL testing of Energy Storage Unit.
11. First draft of Final Report is completed.

**Project Status:**

The project is completed and the final report will be published on the Energy Commission website.

## The Next Generation Turbine Development Project

**Contract #:** 500-97-032

**Contractor:** Wind Turbine Co.

**Contract Amount:** \$950,000

**Match Amount:** \$6,935,733

**Contractor Project Manager:** Lawrence Miles (425) 637-1470

**Commission Contract Manager:** Michelle Pantoya

**Status:** Completed

### Project Description:

The purpose of this project was to design, develop and demonstrate a utility scale wind turbine that will produce electricity at prices that do not need subsidies or premiums to compete in the emerging electricity marketplace. At 250 kilowatts, this turbine is a horizontal axis, 2-blade, downwind turbine that brings together a number of concepts previously employed in other turbines of this design. In addition, this turbine is the first 2-blade downwind configured wind turbine to be developed in over 15 years, and is believed to be the first turbine to be completely designed employing newly available computer analytic codes that model wind turbine behavior and performance. By designing the turbine as a complete system, WTC is able to substantially improve turbine performance while significantly reducing weight compared with conventional wind turbines. Reducing weight lowers manufacturing costs which, together with improved performance leads directly to lower cost electricity. This machine will be well suited for both grid-connected, wind farm applications and for stand alone applications in combination with other generating and/or energy storage technologies.

### This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by increasing the likelihood that wind energy will not only remain a viable source of renewable electricity, but will actually supply a growing share of the electricity consumed in the state.
- Improving the energy cost/value of California's electricity by developing a wind turbine capable of producing electricity at prices competitive with the lowest cost sources of conventional electricity generation currently recognized to be natural gas-fired combined-cycle combustion turbines.
- Improving the environmental and public health costs/risks of California's electricity by reducing air pollution and eliminating emissions that are believed to cause global warming.
- Improving the safety of California's electricity by employing a unique tubular tower design of sufficient diameter to provide an internal passage from the ground to the tower top (nacelle).

### Proposed Outcomes:

1. Bring to market readiness a utility scale wind turbine that is cost competitive with other sources of energy generation.
2. Develop and field test a proof of concept wind turbine intended to demonstrate the feasibility of concepts and systems employed in the wind turbine, and to validate the computer codes used in design the turbine through testing.
3. Develop a prototype turbine that is intended to be a commercially viable machine.
4. Enhance the development of a commercial product that provides renewable, clean, reliable and cost competitive energy.
5. Aim at reduced capital costs due to weight reductions in key turbine components.

**Actual Outcomes:**

The prototype turbine was designed, built and demonstrated at the National Renewable Energy Laboratory (NREL) test site. The project has achieved all technical objectives of incorporating advance design techniques and innovative engineering solutions in the design of the proof of concept model. Although delays were incurred, the project has remained within budget. The POC has amassed nearly 1000 hrs in attended and unattended operation mode. The POC will continue operations and will serve as a testing and instrumentation platform for the development of the EMD in Phase II of the project at a southern California test site. At this time, the POC will remain at the NREL site for continuous testing and monitoring.

**Project Status:**

Project is complete.

**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

**Status:** Completed

**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 manageable.
- Improving the environment, public health and safety by providing the most reliable and updated data for basing decisions and integrating with existing infrastructure (transmission) and planning strategies.

**Proposed Outcomes:**

1. Updated wind resource maps for California with detailed seasonal and altitude variation data needed for planning and forecasting.
2. 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.
3. Web accessible new maps that are in a format that can also be immediately integrated with existing State cartography system (GIS format).
4. Reliable wind resource data to assist wind project developers.
5. Reliable upper altitude ( $\geq 50$  meters) wind data to assist wind turbine manufacturers in developing safe, efficient and affordable wind turbines.

**Actual Outcomes:**

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.

**Project Status:**

The project has been completed.

## **REN Projects Completed in 2001**

## Renewable Technology Options & Green Power Marketing - Target 84

**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

**Status:** Completed

### 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.
- 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, wind power 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:**

The project has been completed.

## **REN Projects Completed in 2000**

## California Renewable Energy Technology Market & Benefit Assessment

**Contract #:** 100-98-001 **Project #:** 26

**Contractor:** Electric Power Research Institute (EPRI)

**Subcontractors:** Global Energy Concepts

**Project Amount:** \$340,352

**Contractor Project Manager:** Chuck McGowin (650) 855-2445

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

**Status:** Completed

### Project Description:

The purpose of this project is to develop an understanding of the current and future performance and costs of renewable energy technologies and resources in California. The project encompasses a multi-phase program that will complement the market analysis performed by the Renewable Energy Program and quantify the benefits of renewable energy research and development (R&D) programs. It also addresses technological issues confronting the manufacturers and developers of renewable energy systems in California. Project results will include renewable resource maps of California, descriptions of renewable energy technologies and their status, market assessments, likely development pathways, current and projected cost and performance, potential for quantified environmental benefits, descriptions of evolving markets and service, and data on key customers and players in the industry. Renewable energy technologies to be addressed include biomass and waste fuels, geothermal, small hydro, solar photovoltaic, solar thermal, wind power, and ocean or tidal current power.

### This project supports the PIER Program objectives of:

- Improving energy cost/value by helping make renewable electricity more affordable, cleaner, reliable, and secure.
- Improving the reliability/quality of California's electric system by identifying issues with a direct impact on research, development and demonstration cost-competitiveness, reliability, dispatchability, and power quality.
- Strengthening the California economy by analyzing market trends, quantifying benefits, and identifying important manufacturers, developers and projects.
- Improving the environmental and public health costs/risks of California's electricity by increasing the proportion of environmentally clean renewable technology in the California energy mix.

### Proposed Outcomes:

1. Identify the current status of renewable technology in California, including the type, location, capacity, duty cycle and operating characteristics of renewable energy generation current deployed in the state.
2. Identify the total market size of each technology in California and how it is affected by regulatory and policy issues such as air quality, utility deregulation, green markets, recovery of stranded costs, and federal tax credits.
3. Assess the economics of renewable energy generation.
4. Identify potential new players in California's renewable energy marketplace.
5. Characterize the technologies most likely to succeed in both large- and small-scale markets.
6. Quantify renewable energy benefits and summarize market data.

### Project Status:

The project has been completed.

## California Wind Energy Forecasting System

**Contract #:** 100-98-001 **Project #:** 23

**Contractor:** Electric Power Research Institute (EPRI)

**Subcontractors:** Risoe National Laboratory(Denmark) : TrueWind Solutions, LLC : University of California, Davis : Weather Service International

**Project Amount:** \$508,344

**Contractor Project Manager:** Chuck McGowin (650) 855-2445

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

**Status:** Completed

### 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 objectives 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.
- Strengthening the California economy by encouraging deployment of new wind plants.

### Proposed Outcome:

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:**

The project has been completed.

## Photovoltaic (PV) Chargeport Demonstration

**Contract #:** 500-97-011 **Project #:** 3

**Contractor:** San Diego Gas and Electric Company

**Project Amount:** \$90,000

**Contractor Project Manager:** Anne Brandon (619) 654-1113

**Commission Contract Manager:** Jamie Patterson (916) 657-4819

**Status:** Completed

### **Project Description:**

The purpose of this project was to demonstrate the integration of electricity-generating photovoltaic (PV) panels into a covered parking port to charge electric vehicles. This application of PV will illustrate how the panels can be integrated into the current electrical system for practical applications.

### **This project supports the PIER Program objective of:**

- Improving the environmental and public health costs/risks of California's electricity by providing a clean source of electricity for zero-emission vehicles.

### **Proposed Outcome:**

1. Establish guidelines for future deployment of PV's for electric vehicle charge stations without the need for extensive engineering.

### **Actual Outcome:**

1. This project demonstrated that photovoltaics can be integrated with electric vehicle chargeports to partially offset the amount of electricity used to charge electric vehicles.

### **Project Status:**

The project has been completed.

## Renewable Technology Options and Green Power

**Contract #:** 100-98-001 **Project #:** 18

**Contractor:** Electric Power Research Institute (EPRI)

**Subcontractors:** D. Iem Dba Augenstein : Edward A. Holt : Karen Conover : Dr. J. M. Morabito : Thomas Morton : Ron Nierenberg : Rla Consulting : Patricia Weis Taylor : Wind Economics & Technology, Inc. : Ascension Technology : Cedar Falls Utilities : Central & South West Services, Inc. : City of Brownfield, Texas : Cummins Power Generation, Inc. : Fortum Power and Heat : Foster Wheeler Development Corp : Green Mountain Power Company : Kansas Electric Utilities Research Program : Nebraska Public Power District : Nevada Power : New York State Electric and Gas : Pennsylvania State University : Princeton University : Resolve, Inc. : Risoe National Laboratory(Denmark) : Southern Research Institute : Tennessee Valley Authority : University of Delaware : University of Illinois, Urbana : University of South Florida : University of Texas, Austin : York Research Corporation

**Project Amount:** \$678,480

**Match Amount:** \$3,694,856

**Contractor Project Manager:** Dan Rastler (650) 855-2521

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

**Status:** Completed

### 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 PV interconnections. 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 energy cost value 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.
- 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. Provide accurate information on wind power technology, markets, and issues to increase the potential for its application in California.
2. Develop a wind forecasting capability to reduce the financial risk for wind generators to bid to supply real-time and next-day wind energy and ancillary benefits to the California Independent System Operator (ISO), Power Exchange (PX), and Automated Power Exchange (APX).
3. Provide accurate information on photovoltaics technology, markets, and issues to increase the potential for its application in California.

4. Provide accurate information on biomass technology, markets, and issues to increase the potential for its application in California.
5. Conduct a Tailored Collaboration entitled "Biomass Cofiring with Natural Gas in California: Phase I Study" to identify feasible options for integrating biomass use with natural gas power systems.

**Actual Outcomes:**

1. Wind power information.
  - Performance test results were compiled from the DOE-EPRI Wind Turbine Verification Program, which features seven projects conducted throughout the world, documenting data on operations and availability of five different leading technologies. Findings were published in news bulletins and eight technical reports.
  - A report entitled Wind Power Productivity Improvement and Procurement Guidelines was published.
  - Improvements were suggested to the wind technology of Zond, the only large U.S. manufacturer of wind power technology, which is located in California.
  - The EPRI Renewable Energy Technology Assessment Guide (TAG-RE) was published with a section on wind power. The TAG-RE provides comprehensive, detailed information on the technology status, development issues, performance, cost, installed capacity, and markets for renewable technologies.
  - Information was compiled on wind power as part of EPRI's renewable energy briefing materials, brochures, CD-ROM, and web site.
2. Wind power forecasting.
  - Development of a modeling system to issue twice-daily forecasts of hourly wind generation was initiated in parallel by three different companies. Development and testing are to continue in 2001.
  - A report was published on the European Union wind energy forecasting model development and testing.
3. Photovoltaics (PV).
  - The EPRI Renewable Energy Technology Assessment Guide (TAG-RE) was published with a section on solar PV.
  - Information was compiled on solar PV as part of EPRI's renewable energy briefing materials, brochures, CD-ROM, and web site.
  - Guidelines were provided for identifying, planning, and implementing high-value PV systems, as well for interconnection with the grid.
  - EPRI representatives attended meetings of the Utility Photovoltaic Group to assist in planning and execution of the national PV Rooftop Initiative.
4. Biomass.
  - The EPRI Renewable Energy Technology Assessment Guide (TAG-RE) was published with a section on biomass.
  - Information was compiled on biomass as part of EPRI's renewable energy briefing materials, brochures, CD-ROM, and web site.
  - The Biomass Cofiring Applications Guide was produced.
  - EPRI monitored and reported on R&D and commercial products and programs that offer improvements in knowledge or performance of biomass crop and energy systems.

5. Tailored collaboration on biomass cofiring.
  - A report was published presenting the major cost and performance parameters of systems that enable natural gas to be augmented by 10% biomass fuel. The report provides estimates of the extra cost for the electricity to be generated from biomass.
  - Field test results were published from the Bailly and Seward demonstrations.

**Project Status:**

The Commission's participation in this target ended as of December 31, 2000.

## **REN Projects Completed in 1999**

## Photovoltaics

**Contract #:** 500-97-012 **Project #:** 11

**Contractor:** Edison Technology Solutions/Southern California Edison

**Subcontractors:** Utility PhotoVoltaic Group : United States Department of Energy : Emerging Renewables

**Project Amount:** \$1,000,000

**Contractor Project Manager:** Steve Taylor (626) 815-0530

**Commission Contract Manager:** Jamie Patterson (916) 657-4819

**Status:** Completed

### Project Description:

The purpose of this project was to operate and monitor twelve photovoltaic (PV) systems to evaluate their year-round system performance and efficiency. This evaluation was to document that photovoltaics are applicable on a wide scale to the typical building types located in the dense urban areas of Southern California.

### This project supports the PIER Program objectives of:

- Improving the environmental and public health costs/risks of California's electricity by documenting the application of a clean electrical generation technology.
- Improving the reliability/quality of California's electricity because PV offers an attractive, environmentally benign renewable energy alternative for distributed electrical generation.

### Proposed Outcomes:

Support Edison Technology Service's (ETS) Solar Neighborhood Program by helping to commercialize photovoltaic technology, educate and increase public awareness, and deploy photovoltaics into high-value, high-visibility applications by evaluating system performance and efficiency as compared to expected results, and evaluating the seasonal effects of year-round PV operations in California.

### Actual Outcomes:

Properly designed and situated PV systems were shown to operate within 15 percent of their expected system efficiency specifications.

The seasonal effects of the various PV systems showed that with increasing panel temperatures, efficiencies decreased. Conversely, when the panels were cooler at the same irradiance level, system efficiency increased. Increasing daylight hours in the summer increased overall energy production. The decreased panel efficiency occasioned by increased summer temperatures was more than offset by longer daylight hours. Peak power reduction was offset by increased energy production.

### Project Status:

The project has been completed.

## Solar Two

**Contract #:** 500-97-012 **Project #:** 10

**Contractor:** Edison Technology Solutions/Southern California Edison

**Project Amount:** \$1,200,000

**Contractor Project Manager:** Kon McQuiston (626) 815-0520

**Commission Contract Manager:** Alec F. Jenkins (916) 654-4597

**Status:** Completed

### Project Description:

This project completes the testing and evaluation of the 10 MW Solar Two Central Receiver Project. Solar Two uses concentrated solar energy to produce steam for electric generation. It is a proof-of-concept power plant that demonstrates the practical combination of the solar central receiver concept and the use of molten salt as an efficient, nontoxic heat transfer and energy storage fluid. The central receive/molten salt design is presently the only practical technology for collecting and storing solar thermal energy for electric generation on demand, whether that demand is hours or days after the energy has been collected.

### This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by using a sustainable energy resource to diversify the State's electricity supply system.
- Improving the energy cost/value of California's electricity by overcoming the intermittent nature of traditional solar electric generation so that even base load power can be provided.
- Improving the environmental and public health costs/risks of California's electricity by using a zero emission generation technology with a nontoxic energy storage medium (molten salt).
- Improving the safety of California's electricity by using a nonflammable energy transfer fluid (molten salt).

### Proposed Outcomes:

1. Test and validate the technical characteristics including performance of the nitrate salt receiver, energy storage system, and steam generator subsystems and generation dispatch capability.
2. Improve the accuracy of economic projections for commercial projects by increasing the database for capital, operating, and maintenance costs.
3. Document overall project results for use by public and private R&D programs and the solar industry to foster wider interest in commercial plants.

### Actual Outcomes:

1. Completed all primary tests and data collection goals, including demonstrating full operational flexibility and successful operation of an advanced receiver panel technology.
2. Specific technical outcomes:
  - Gross turbine output as a function of heat input to the steam generator agreed well with design estimates.
  - The efficiency of the molten salt receiver agreed well with design predictions.
  - The energy storage subsystem fully met efficiency predictions.
  - Between July 1 and July 7, 1998, the plant demonstrated a key advantage of the molten salt central receiver by delivering 24 hour a day continuous solar-electric

power to the grid (153 hours). The project has therefore demonstrated full dispatch capability.

3. Improved the accuracy of economic projections by obtaining actual performance data for use in scaling the design performance prediction model, Solergy.
4. Improved plant cost predictions by documenting refinements in operation and maintenance procedures and expected outcomes in cost and performance, as well as design and operational refinements to be incorporated in the subsystems for commercial plant.
5. SunLab (the solar thermal program collaboration between the National Renewable Energy Laboratory) is documenting the overall project results for use by public and private R&D programs and the solar industry to foster wider interest in commercial plants.

**Project Status:**

The project has been completed.