CALIFORNIA
ENERGY
COMMISSION

2004 Annual Review of the PIER Program Volume 7 – Energy Systems Integration Project Summaries

STAFF REPORT

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ESI Multi-Year Projects Started in 2004

California CHP Market Assessment

Contract #: 500-01-025 **Work Authorization #:** E2I-WA-011
Contractor: Electricity Innovation Institute
Project Amount: $278,000
Contractor Project Manager: Ellen Petrill (650) 855-8939
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Active

Project Description:
The goal of this project is to quantify the potential contribution of combined heat and power (CHP) to the California energy mix, to define the key factors that influence end-user adoption, and to provide the CEC with options and the associated costs/benefits for incenting CHP to help shape the policy discussions in future workshops and stakeholder meetings.

This project supports the PIER Program objectives of:

- Improving the reliability, quality, and sufficiency of California's electricity by performing analysis of economic feasibility and possible financial alternatives.
- Connecting to near-term market applications by identifying key issues to effective CHP deployment.

Proposed Outcomes:

1. Assess the current CHP capacity and impact of the Self-Generation Incentive Program (SGIP) and CHP market penetration in California.
2. Assess the current and future cost and performance of CHP technologies and thermally activated technologies such as absorption cooling.
3. Evaluate CHP with traditional heat recovery and combined cooling, heating and power (CCHP).
4. Estimate the technical market potential for CHP and CCHP based on evaluation of California business activity.
5. Estimate the economic market potential for CHP and CCHP and market penetration for a range of scenarios.
6. Quantify the economic and environmental benefits of future CHP market penetration.
7. Analyze the incentive options including their costs and benefits to promote the CHP market opportunity.

Project Status:
Project is active and on schedule. The first deliverables are due in March 2005. The project is scheduled to be completed by June 2005.

CEIDS Consortium for Electric Infrastructure to support a Digital Society

Contract #: 500-02-014 **Work Authorization #:** E2I-WA-112
Contractor: Electricity Innovation Institute
Project Amount: $500,000
Contractor Project Manager: Mark Samotyi
Commission Contract Manager: Laurie ten Hope (916) 654-5045
Status: Active

Project Description:
The CEIDS collaborative research initiative supports recommendations made in Electrical Power Research Institute's (EPRI) *Electricity Technology Roadmap*-EPRI's long-term strategic vision, forecasting society's electrical needs on a 25-year basis. The partnership between the Energy Commission and the CEIDS program will work towards actively developing a strategic framework to upgrade the electrical delivery system. The Energy Commission served as one of the partners of the CEID's Consortium which is focusing on the long-term vision of transforming the power delivery system to a modern intelligent system that will meet society's needs in the future.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by development of business cases for the new functionalities of the power delivery system of the future.
- Improving the reliability, quality, and sufficiency of California's electricity by identifying new science and technology developments needed for the power delivery system of the future.

Project Status:
PIER participated in this collaborative effort for one year. CEC Participation ended December 30, 2004. Because PIER has access to all results of the collaborative effort from the beginning of the program, all results delivered to date are listed below. Deliverables can be found on the EPRI website at:

⇒ http://www.epri-intelligrid.com/intelligrid/home.jsp

Creation of the Vision of the Power Delivery System of the Future

- Developed a high level vision for the power delivery system of the future – *CEIDS Master Plan, July 2003.*
- Developed a set of functional requirements for the power delivery system of the future – *Integrated Energy and Communications System Architecture Vol. II, Functional Requirements, August 2004.*

Development of Open Platforms around Critical Integrating Technologies

- Communications:
  - Developed a set of requirements for the communications infrastructure needed to support the for the power delivery system of the future – *Integrated Energy and Communications System Architecture Vol. II, Functional Requirements, August 2004.*
  - Developed a methodology and tools for utilities to use when designing communications systems – *Integrated Energy and Communications System Architecture Vol. I, User Guidelines and Recommendations, August 2004.*
  - Developed recommendations for standards and technologies for utilities to use when designing and installing communications systems– *Integrated Energy and*

Communications System Architecture Vol. I, User Guidelines and Recommendations, August 2004.
  - Developed draft communications object models for fuel cells and reciprocating engines - *DER/ADA Object Model Report Final Draft, December 2003.*
  - Initiated work to define the requirements for a communications portal that will enable consumers to participate in energy markets and to receive energy-related services.
  - State of the art and trends of communications in utilities systems *Inventory of Utility Communications, March 2004.*
- Examples of how the IntelliGrid Architecture is being used:
  - The "strawman reference design for demand response information exchange" published by the California Energy Commission in November 2004.
  - The OpenAmi Infrastructure with Demand Response Specification Document currently developed by the OpenAmi users group.
  - Designing and installing an advanced remedial action scheme at SRP (work performed by GE).
- Computing
  - Initiated work to develop the distributed computing architecture needed to support the IntelliGrid (*November 2004*).

Clarify Key Areas of Uncertainty

- Developed a methodology for determining the appropriate level of quality and reliability for energy consumer – *Analysis of Extremely Reliable Power Delivery Systems – November 2002.*
- Published a study that determines the cost of power outages and disturbances in the U.S. – *The Cost of Power Disturbances to Industrial and Digital Technology Companies, July 2001.*
- Published a study on how distributed generation can be used in the operations of power systems under normal operating conditions – *Studies of Distribution Operations to Aid in Determining Object Models for Distributed Energy Resources, December 2003.*
- Initiated a study on how distributed generation can be used in the operations of power systems under emergency conditions (*December 2004*).
- Published business case analysis for power electronic-based power flow controllers - *Business Case Assessment for power electronic-based power flow controllers, December 2003.*
- Published business case analysis for a consumer communications portal – *Business Case Assessment for Energy Service Portals, March 2004.*

Identifying New Science and Technology Developments Needed for the Power Delivery System of the Future

- Published a technology analysis with a recommended approach for developing a consumer communications portal – *Energy Service Portal Development – Assessment and Recommendations, December 2003.*
- Published a technology analysis that identified key technology development activities needed for power electronic-based power flow controllers – *Advanced Power Electronics Technology Assessment – December 2003.*

Influencing and Contributing to Relevant Standards Development Efforts

- Created IEC and IEEE working groups on communication, command and control of distributed energy resources.

Demonstrations of Critical Aspects of the New Functionalities That Make Up the Power Delivery System of the Future

- Initiated several demonstration projects with CEIDS partners implementing the methodology, tools and recommendations for installing communications systems.

CERTS - Microgrid Laboratory Test Bed

Contract #: 500-03-024
Contractor: Lawrence Berkeley National Laboratory
Subcontractors: Northern Power Systems
Contract Amount: $2,955,000
Contractor Project Manager: Joseph Eto (510) 486-7284
Commission Contract Manager: Bernard Treanton (916) 654-4512
Status: Active

Project Description:
The objective of this project is to create the technologies and control strategies needed to capture the full potential of distributed energy resources to improve the reliability of the California interconnected power system via the Micro Grids concept. The objectives include:

- Consideration of control systems, including the sensors and instruments necessary to gather intelligence for real-time power management.
- Dispatch or coordination among distributed generation resources.
- Improved modeling techniques to better characterize the technologies and their impacts on the distribution system (and ultimately the transmission).

With correct placement and control, it should be possible to increase utility system reliability, lower the cost of power deliver, improve power quality, and reduce the environmental impacts of producing and transmitting electricity.

This contract is a follow-up of an existing micro-grid contract that evaluates the feasibility of the concept and included some bench scale testing of components. This contract involves the scaled up testing of all components, hardware, and control systems in a laboratory setting. This contract will involve two subcontracts: one is a micro-source manufacturer and the other is a Distributed Energy Resources (DER) engineering firm, they will provide 3 generators with modified inverters for use in the laboratory test bed demonstration. The initial phase of work will also require the DER engineering firm to develop and conduct factory tests for three modified inverters for the three 60 kilowatt (kW) generators that implement aspects of the Consortium for Electric Reliability Technology Solutions (CERTS) Micro-grid control algorithms. The second phase will place these three units at a utility laboratory test site to conduct a test demonstration.

At the present time LBNL has a contract in place with Northern Power. Northern Power manufactures DER equipment and inverters.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by reducing grid loses and increasing kW injection.
- Improving the environmental, public health, and safety of California's electricity by increasing the use of renewable energy sources and by multiplying the number of generators.
- Improving the reliability, quality, and sufficiency of California's electricity by using Distributed Energy Resources to improve power quality and reduce the effect of power failure on the grid.

Proposed Outcomes:

1. Improve knowledge and integration of DER technologies to the grid.
2. Improve grid reliability and reduce end of line voltage sag.
3. Reduce the impact of grid power failure on utility's customers.

Project Status:
The project is active, on schedule and on budget.

- Although the project encountered a hurdle (lack of response from Capstone to supply micro-turbines), the project is expected to be completed on time by 12-31-2007. Technical work done on the inverter by Northern is almost completed and delivery of the equipment is expected by late summer 2005. LBNL is evaluating a new generator supplier and progress has been made to find a utility test site for the testing.
- LBNL is investigating three utility companies for potential micro-grid test sites.

Demand Response Research Center

Contract #: 500-03-026
Contractor: Lawrence Berkeley National Laboratory
Contract Amount: $7,999,970
Contractor Project Manager: Mary Ann Piette (510) 486-6286
Commission Contract Manager: David Michel III (916) 651-9864
Status: Active

Project Description:
This project will develop a "Demand Response Research Center" (DRRC) which will be multi-institutional in concept and operation. Lawrence Berkeley National Laboratory (LBNL) will host the DRRC and guide its development as well as provide technical, operational and planning duties. The DRRC will solicit stakeholder input and adopt research topics.

To ensure that the R&D planning is well balanced and relevant, planning will begin with an evaluation based on the following information:

- What State policies does DRRC research intend to address?
- What is the range of demand response research topics considered?
- How should research be prioritized?
- Who should provide technical guidance and how should this group function?

Research at the DRRC will follow PIER policy by addressing key questions before beginning each project. The research planning process will maintain the flexibility to adapt to changes from outside research methods and results. The DRRC will consider a research planning process that combines scenario analysis with an assessment of current demand response Research and Development and gap analysis. The DRRC will complement, reinforce and leverage current PIER Energy Systems Integration, Buildings, and Industrial Program research to avoid overlap.

The research agenda for the DRRC will be carefully coordinated with the evaluations of utility demand response programs and tariffs in California, throughout the nation and beyond, many of which are experimental in nature. Results of these experiments are expected to provide critical information on the feasibility and effectiveness of various demand response programs, tariffs, technologies, and information systems. In particular, the DRRC will closely track the work and results of the three Demand Response Working Groups established under CPUC Rule-making 02-06-001.

A major element of the DRRC will be the strong market connection developed for each and every project. A concerted effort will be made to involve a variety of stakeholders in DRRC planning and on the actual research teams. Members of the Partners Planning Committee are likely to be representatives of the most direct stakeholders of the DRRC, including:

- Control, Metering and Information System Developers.
- Aggregators and Program Implementers.
- Utilities.

The overall technical goal of this project is to facilitate greater demand response in California to prevent future energy crises.

The specific, technical objectives upon which this project's success will be evaluated are:

- Develop new demand response techniques and technologies.
- Valuate and demonstrate where new techniques and technologies are applicable.
- Evaluate demand response systems for utilities, customers, and aggregators.
- Evaluate demand response decision making and technology adoption perspectives.

The overall economic/cost goals of this project are as follows:

- Prevention of future electricity crises.
- Reduction of average electricity prices.
- Promote price responsiveness including equity, through cost of service pricing, and customer control of electricity usage and bills.

This project supports the PIER Program objectives:

- Improve the energy costs and value of California's electricity through the improvement of demand response methods.
- Improve the reliability/quality of California's electricity by reducing electricity use when the electric grid is constrained.

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Proposed Outcomes:

The DRRC will focus on the following activities:

1. Create a roadmap for demand response in California by identifying and conducting the R&D needed to solve practical and technical demand response issues.
2. Establish multi-institutional partnerships to broaden the expertise of DRRC researchers and leverage funding.
3. Foster connections with stakeholders through outreach efforts.
4. Sustain long-term attention to demand response research topics.
5. Conduct demand response related research, development, demonstrations, and technology transfer.

Project Status:

The project is active and is expected to be completed by June, 2008.
The following has been accomplished:
Established the "Demand Response Research Center" hosted by Lawrence Berkeley National Laboratory.

- Co-sponsored PIER-Energy Systems Integration Demand Response Symposium.
- Developed the Draft Scoping Study on future research.
- Coordinated with other demand response research efforts: Center for the Study of Electricity Markets, Consortium for Electric Reliability Technology Solutions, Demand Response Enabling Technology Development.
- Conducted outreach with potential partners.

Conducted research activities under three projects

- Performance Platform: Case Study Analysis for Automated DR in Large Facilities.
- Program and Tariff Analysis.
- Demand Shifting with Thermal Mass.

Demonstration of ZBB Energy Storage Systems

Contract #: 500-03-031
Contractor: ZBB Energy Corporation
Contract Amount: $1,873,133
Match Amount: $602,698
Contractor Project Manager: Peter Lex (252) 253-9800
Commission Contract Manager: David Chambers (916) 653-7067
Status: Active

Project Description:
This project is designed to address the pressing need for validation and evaluation of the benefits of energy storage when applied to the deferral of distribution system upgrades. In addition to providing financial benefits, the system will demonstrate the use of energy storage in a practical grid-connected application. It will do so with essentially no air emissions or other environmental drawbacks, as opposed to other sources of generation such internal combustion engines or combustion turbines. A successful demonstration will open the door to future use of energy storage and a growing market for new technology. This is a critical time for energy providers to make decisions on the power systems of the future, so it is timely for the Commission to undertake this demonstration at this time.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by deferring costly substation infrastructure upgrades.
- Improving the reliability, quality, and sufficiency of California's electricity by providing support to the distribution system in the form of frequency and voltage control.
- Providing greater choices for California consumers by increasing the number of new technologies providing increased reliability/sufficiency of power to consumers by one.
- Connecting to near-term market applications by effectively reducing barriers to commercial acceptance thru conducting a successful large-scale utility demonstration.

Proposed Outcome:

1. Evaluate the economic benefits of distribution system upgrade deferral by operating a zinc-bromine battery electric energy storage system at a PG&E distribution node.

Project Status:
The project is on schedule and budget. The project is scheduled for completion in December 2007.

DUIT-Distributed Utility Integration Test

Contract #: 500-03-034
Contractor: Distributed Utility Associates
Subcontractors: Pacific Gas and Electric Company : Endecon Engineering
Contract Amount: $2,976,437
Match Amount: $1,890,060
Contractor Project Manager: Susan Horgan (925) 447-0604
Commission Contract Manager: David Michel III (916) 651-9864
Status: Active

Project Description:
The Distributed Utility Integration Test (DUIT) concept in the broader scope defines a large scale set of tests designed to validate newly adopted interconnection standards such as California's Rule 21 and the national Institute of Electrical and Electronics Engineers (IEEE) 1547 standard. The goal of DUIT is to lower the cost of interconnecting distributed generation into the electricity distribution system and ultimately aid in grid support. The testing also goes beyond standards validation and looks at interaction issues which could arise from the interconnection of diverse DER technologies and their interaction with the electrical distribution system from low to high penetration levels. DUIT is unique in that testing at penetration levels up to 60-80% is expected and well above currently contemplated levels of 10%-15%. A complete set of DUIT test protocols addressing twelve segmented topics such anti-islanding, voltage regulation, stability, protective relay coordination, and others will be the focus of work. Each segment is then broken down into ten's to hundred's of tests depending on the topic being addressed.

The two DUIT topics to be covered in this scope of work include voltage regulation and stability. These two segmented topics have been prioritized by protection engineers as major concerns when distributed generation reaches medium to high penetration levels on the distribution system. In the DUIT set of test protocols on these topics, there exists a total of 60 identified tests at this time. These tests are wide in range and scope and consider a wide range of DER such as inverter based DER (prime movers include photovoltaic, batteries, fuel cells, microturbines) together with rotating equipment including synchronous and induction generators.

The entities involved in the development of DUIT test protocols includes the Contractor, the Energy Commission, NREL, DOE, UL, DER equipment manufacturers and a large contingency of utility protection engineers from across the country. The DUIT test protocols developed by this team are identified as addressing areas of most concern as diverse DER continues to populate the distribution system. The development of the test is in parallel with the development of standards including IEEE 1547, California's Rule 21, UL 1741 and others. A significant objective of the DUIT test plan is to provide data which has never before been collected, and will support the development and implementation of these standards.

This project supports the PIER Program objectives:
By allowing easy and safe interconnection of DER to distribution systems, this agreement will:

- Improve the Energy Cost/Value of California's Electricity.
- Improve Reliability, Quality, and sufficiency of California's Electricity.
- Provide greater choices for California Consumers.

Proposed Outcomes:

1. Procure additional DER devices, recruit team members and build consensus on testing needs.

2. Develop the next phase of the testing plan.
3. Update the test management control and data acquisition system.
4. Undertake all pre-installation and facility preparation engineering for the upgrade to a 7 megavolt-ampere (MVA) distribution system.
5. Install and setup of new DER devices for testing.
6. Develop and validate models as testing is being performed.
7. Conduct the prioritized DER tests described in the Test Plan.
8. Disseminate the results of the testing results to assist in utility adoption of DR.

Project Status:
The project is active and is on schedule to begin work in the summer of 2005.

Electric Grid Infrastructure Security Initiative: Phase 1

Contract #: 500-02-014 **Work Authorization #:** E2I-WA-114
Contractor: Electricity Innovation Institute
Project Amount: $200,000
Contractor Project Manager: Donn Baker (650) 855-1098
Commission Contract Manager: David Chambers (916) 653-7067
Status: Active

Project Description:
The Electric Grid Infrastructure Security Initiative (ISI): Phase 1, was formed to undertake a focused effort to identify key vulnerabilities in the electric power grid and where appropriate develop hardware, software and other tools to mitigate the impact of terrorist attacks on the North American electric grid.

The ISI grew out of Electrical Power Research Institute's (EPRI) rapid response to the terrorist attacks of September 11, 2001. Building on experience gained from the Western States Power Crisis, EPRI assembled its own inter-disciplinary team to prepare the *Electricity Infrastructure Security Assessment*, which provided a preliminary analysis of potential terrorist threats. ISI was established to put the recommendations of this report into action.

The Energy Commission participation includes participation by PG&E, SCE, SDG&E, and CA ISO in order to ensure that the research addresses the issues that face California and to increase the likelihood that the results will be embraced by California's utility industry.

This project supports the PIER Program objective of:

- Addresses important RD&D gaps by conducting electric grid infrastructure security research development and demonstration with California's IOU, CAISO and other National Departments and Agencies responsible for security.

Proposed Outcomes:

1. Conduct meetings of the collaborative.
2. Prepare reports documenting the research.

Project Status:
Active and on schedule and budget. The project is expected to be completed by June 2005.

Evaluation of Policy Impacts on the Economic Viability from a Project Owner's Perspective of California Based Distributed Generation/Combined Heat and Power

Contract #: 500-04-015
Contractor: Competitive Energy Insight Inc.
Contract Amount: $128,621
Match Amount: $23,442
Contractor Project Manager: Steve Provol (858) 566-0221
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Active

Project Description:
There are a number of challenges to achieving greater and more successful penetration of distributed generation (DG) and combined heat and power (CHP) in California. The specific goals of this project are to provide a better understanding of the DG project economic factors affecting deployment. The outcome will provide decision makers including the Energy Commission, The California Public Utilities Commission, and California stakeholders with valuable information about policies that affect the economic viability of DG projects.

Competitive Energy Insight, Inc. (CEI) will perform an economic evaluation of three typical DG/CHP applications in each of the three investor-owned utility service territories in California. Additionally, this project will also evaluate four cases regarding project economics of DG use at California dairy facilities. The analysis will be performed applying CEI's *EconExpert-IAT* and *EconExpert –DG* software product to understand the economic and risk factors associated with DG/CHP applications from the perspective of the various stakeholders including the building owner and private developers who might participate in such transactions.

By applying CEI's unique software products, the Energy Commission will more fully understand the cost/benefit tradeoffs and risk allocations associated with DG/CHP under alternative policy and tariff scenarios.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by assessing the drivers and risks that potential DG users face at a project level. This helps provide a clearer understanding of the impacts of policy and tariff structures of DG/CHP economic viability in California.

Proposed Outcomes:

1. Analyze the cost and benefits associated with DG/CHP from the site and project owner's perspective.
2. Conduct sensitivity analyses to address DG/CHP economic impacts of key regulatory and policy factors including:
    - Electric Tariffs.
    - Rebate and incentive programs.
    - Income tax incentives.
    - Fuel pricing and markets.
    - Technology type and operating characteristics.

Project Status:
This project was approved at the December 15, 2004 Business Meeting. The official kickoff will be in early January 2005.

Verification of Optimal Methodology

Contract #: 500-04-008
Contractor: New Power Technologies
Subcontractors: Optimal Technologies (USA) Inc.: Cupertino Electric, Inc.
Contract Amount: $5,427,726
Match Amount: $509,750
Contractor Project Manager: Peter Evans (650) 948-4546
Commission Contract Manager: Linda Kelly (916) 654-4815
Status: Active

Project Description:
This project will demonstrate the methodology developed under PIER contract 500-01-039 to quantify the potential for greater network efficiency and performance from ideally-situated distributed energy resources (DER). In this case, a demonstration of the methodology will apply to a larger more complex investor-owned power delivery system. Additionally, this project will also evaluate the impact of changes to the configuration of the distribution system and additions on both the distribution and transmission system. This will be done by evaluating the benefits of switchable or automated distribution devices (e.g. remotely operable switches and capacitors), under varying load conditions. To complete the analysis, the range of initiatives developed using the methodology will be quantified. The project will take into account the value of network benefits, reliability enhancements, and capital and O&M cost reductions or deferrals.

The final task of this project is a field demonstration which will demonstrate the veracity of the simulation of the distribution and transmission systems as a single, integrated system, as well as the efficacy of the recommended recontrols and DER additions developed using the Methodology.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity system by developing an analytical tool that can identify where DER and other non-wire alternatives can be located to help alleviate power quality and T&D capacity and congestion problems in the State.
- Providing more choices to California consumers by helping overcome the barriers to the deployment of distributed energy resources.

Proposed Outcomes:

1. Demonstrate the Methodology developed under PIER contract 500-01-039 to use AEMPFAST (Advanced Energy Management & Power Flow Analysis System Technology) to determine idealized placement of DER.
2. Evaluate the potential network benefits of distribution-level topology reconfigurations.
3. Determine the potential network benefits of switchable or automated distribution devices under varying load conditions.
4. Assess reliability improvements as a network benefit by evaluating proposed measures.
5. Develop an expanded set of potential measures available to achieve pre-defined operation or functional objectives for the network that includes both wires and non-wires measures, with a direct basis for comparison.

Project Status:
The project is active and on schedule. The Kick-off Meeting for this project was held on November 15, 2004. Working with Southern California Edison, work has commenced on identifying the subject study circuits and data requirements for the proposed system modeling.

ESI Active Projects from Previous Years

Advanced Switches for Soft Blackouts

Contract #: 500-00-018
Contractor: California State University, Chico Research Foundation
Contract Amount: $800,000
Contractor Project Manager: Bill Wattenburg (925) 938-5955
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Active

Project Description:
The purpose of this project to research methods to lessen the impact of rolling blackouts that can occur in California during Stage 3 power emergencies. During previous Stage 3 power emergencies rolling blackouts have been instituted to prevent total electric system collapse. These blackouts are very expensive to California residents and businesses and are done in a disruptive manner. The process presently disables many critical public safety functions such as traffic signals and streetlights and other public safety functions. This project will allow the State to control rolling outages in a less intrusive manner by accomplishing necessary emergency load reduction while allowing lighting, traffic lights, streetlights and other similar public safety devices to continue operating during "soft blackouts."

The objective of this project is to test Advanced Switches for Soft Blackouts. These switches are designed to turn off 240-volt appliances, while leaving on 120-volt circuits.

The goal of this project is to determine the impacts and consequences of opening one hot leg of 240-volt electric service on electrical appliances and equipment normally found in a residence. The project will also determine the impacts and consequences of connecting both legs of a standard residential service to one side of the transformer, effectively reducing residential service to 120-volts. Finally, the project will determine the effect of doing this to an entire house and group of homes.

In 2002, this contract was amended to expand the scope of the contract to include development of security devices and systems for protecting power plants and substations from terrorist attacks. Two primary research and development activities were included in this amendment. The first is to develop a truck-stopping device that can be attached to heavy-duty truck air brake systems. This device will be either radio or mechanically triggered and will stop heavy-duty trucks by activating their brake systems. The second work is the development of portable truck barriers that can be quickly erected to prevent heavy-duty trucks from crashing into secured areas of power plants or other critical electric transmission system facilities. Together these two technologies provide a systems approach to preventing terrorists with truck bombs from gaining access to critical areas.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electrical system by reducing the impact of electric power outages.

Proposed Outcomes:

1. Determine the technical and economic feasibility of using these advanced switches to implement soft blackouts versus complete blackouts during Stage three power emergencies.
2. Develop and test truck stopping devices and portable truck barriers for protecting power plants and substations.

Project Status:
The Contractor has determined that many household appliances can be safely operated on reduced voltages, but more importantly that appliances are not damaged when this occurs.

One configuration of the advanced switch used on distribution transformers is not technically feasible. Only the meter socket version is feasible. During 2004, the prototype meter socket version was run through automated durability testing at the contractor's laboratory. No abnormal cycling events were noted. Final test results of this testing will be included in the final report for this project which will be completed in early 2005.

Work on terrorist protection systems for power plants and substations continued in 2004. Working in collaboration with DOE, National Department of Homeland Security and California Highway Patrol, the contractor has successfully developed and tested the mechanical and remote controlled version of the truck-stopping device. The California Highway Patrol is testing these mechanical versions on the road presently with fuel tankers. The radio-controlled version of the truck-stopping device was also successfully developed and tested for applicable use at power plants and substations. Final operational testing of the remote controlled version of the truck-stopping device is slated for February 2005, results of which will be included in the contract final report.

Center for the Study of Electricity Markets

Contract #: PIR-00S-001
Contractor: University of California, Energy Institute; Center for the Study of Energy Markets
Contract Amount: $2,050,000
Match Amount: $200,000
Contractor Project Manager: Severin Borenstein (510) 642-5415
Commission Contract Manager: Mike Jaske (916) 654-4777
Status: Active

Project Description:
The purpose of the grant agreement is for University of California Energy Institute (UCEI) to operate a Center for the Study of Energy Markets (CSEM) to undertake market performance research. Tasks to be performed by the CSEM are divided into 5 categories relating to program management, the performance of research, and the presentation and transfer of research results. CSEM will contribute a diverse array of products useful to decision-makers and the market alike.

The central mission of CSEM is for UCEI staff, UC professors and students, and visiting professors to produce high quality research on the design, performance, and analysis of energy markets. The thrust of CSEM research will be towards more basic research in these areas. Research at CSEM will focus on developing new tools and strategies for the analysis of electricity markets.

Over the period of the grant, CSEM will conduct research in five areas:

1. The reliability in a market-based industry structure.
2. The interaction of demand response and market competitiveness, the political economy of distribution/retail rate structures, and the feasibility and impact of various proposals for providing customer response.
3. The development of tools to analyze the impact of market design on the ability of firms to exercise market power and the ability of decentralized market activities.
4. Systematic analyses of both the benefits and consequences of the various tools for mitigating market power that have been proposed or adopted in electricity markets around the world.
5. Interactions between electricity markets and environmental regulation.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity system by providing assessments of major market structure and performance issues that are a key part of the macro environment influencing the commercialization and adoption of energy technologies.

Proposed Outcome:

1. Conduct high quality research on the design, performance, and analysis of energy markets.

Project Status:
The grant has been operating for about 30 months. The grant is functioning about as intended, with a number of short-term visiting and permanent personnel developing research papers, making presentations at research conferences, and preparing policy overview papers. These were "published" on the UCEI website under the CSEM Working Paper Series. The core UCEI

personnel have conducted a number of outreach activities – multi-day training courses, policy conferences, and are laying the ground work for a newsletter.

The following has taken place:

- 15 research papers have been posted to the CSEM Working Paper website since January 2003:
  ⇒ http://www.ucei.berkeley.edu/pubs-csemwp.html
- March 2004 Workshop.

CERTS Demand Response Amendment

Contract #: 150-99-003 **Project #:** 2
Contractor: Lawrence Berkeley National Laboratory
Project Amount: $895,000
Contractor Project Manager: Joseph Eto (510) 486-7284
Commission Contract Manager: Laurie ten Hope (916) 654-5045
Status: Active

Project Description:
The Lawrence Berkeley National Laboratory, acting on behalf of the Consortium for Electric Reliability Technology Solutions, has completed three related research activities in the area of demand response.

The three activities were guided by two overarching research questions. They are:

- What can the State do to help build a real-time energy information, signaling, and response infrastructure that is flexible and simple enough so that it can address the next energy crises not only the last one?
- What are the most effective strategies (technology, tariffs, etc.) related to deploying a real-time demand responsiveness system that are cost-effective, require minimal end-user interaction, and yet are effective?

The completion of the activities has contributed to improved understanding of the following demand response issues:

1. The current status of California's demand response (DR) capabilities for typical large commercial, semi-industrial and institutional (LCI&I) facilities.
2. Customer response to tariffs.
3. The technologies and systems required by California Independent System Operator (CAISO) so that it can manage a real-time two-way signaling system.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing service interruptions through a rational utilization of the existing infrastructure to implement a significant DR capability in LCI&I buildings.
- Maximizing the market connection by understanding what other states have done and proposing changes to the market that utilize these proven strategies, and yet meet California's unique requirements.
- Improving the energy cost/value of California's electricity by providing the basis for a real-time information and control system at CAISO that can automatically respond to supply-side problems, using load as a resource.

Proposed Outcomes:

1. Evaluate the technological performance of automated demand-response hardware and software systems in large commercial, semi- industrial and institutional buildings.
2. Study a functioning market in New York State that has real-time, demand-response programs that have attracted significant participation and support from large customers for four years in a restructured electricity market.
3. Conduct interviews with CAISO staff to develop a research agenda to identify how responsive loads could increase power system reliability and adequacy, what behaviors

are desirable, and what reliability services (ancillary services) responsive loads could provide.

Actual Outcomes:

1. The first research activity achieved the following objectives:
   - Improved understanding of the status of automated demand responsive building systems, particularly the levels of automation in best practices.
   - Quantified demand-savings response of automated systems.
   - Identified technology gaps and priorities to improve future systems.
   - Provided understanding about key features of the market for DR systems and decision making perspectives about the adoption of DR technology.
   - Developed and tested a real-time signal to initiate an automated demand response.

2. The second project achieved the following technical objectives:
   - Assessed customer response to tariffs based on day-ahead wholesale market prices (i.e., RTP) in a retail competition environment.
   - Assessed relative merits and relationship between alternative programs/strategies (e.g., "real-time pricing" tariffs, price-responsive load bidding programs administered by ISOs) that seek to increase customer participation in electricity markets.

3. The third project made the following findings:
   - Though there has been relatively little impact with demand response programs to date, ISO personnel believe that responsive load has the *potential* to be a significant resource to increase reliability and mitigate price volatility.
   - Demand response must be location specific to have real value.
   - Demand response programs must not increase the CAISO work load.
   - Demand response programs must not degrade the CAISO's ability to forecast load. The response itself must be simple and certain.
   - For a demand response program to be accepted, the benefits for the individual and the power system must be clear to customers, system operators, and regulators.

Project Status:

The first research activity evaluated the technological performance of automated demand-response hardware and software systems in large commercial, semi- industrial and institutional buildings. The goal was to help establish a baseline DR capability by defining the amount of DR that might be available from LCI&I facilities during the next electricity crisis. The baseline includes only already in-place technologies and control strategies. The findings are documented in "Development and Evaluation of Fully Automated Demand Response in Large Facilities" by M. A. Piette, O. Sezgen, D. S. Watson, N. Motegi, and C. Shockman. CEC 500-2005-013. January 2005.

The second research activity studied a functioning market in New York State that has real-time, demand-response programs that have attracted significant participation and support from large customers for four years in a restructured electricity market. The programs were evaluated with respect to how they might be used in California to create a vibrant demand response market. The findings are documented in "Customer Response to Day-ahead Wholesale Market Electricity Prices: Case Study of RTP Program Experience in New York" by C. Goldman, N. Hopper, O. Sezgen, M. Moezzi, and R. Bharvirkar, B. Neenan, R. Boisvert, P. Cappers, D. Pratt. LBNL-54761. June 2004.

The third research activity conducted interviews with CAISO staff to develop a research agenda to identify how responsive loads could increase power system reliability and adequacy, what behaviors are desirable, and what reliability services (ancillary services) responsive loads could provide. The findings are documented in "Demand Response Research Plan" by John D. Kueck and Brendan J. Kirby. ORNL/TM-2003/235. September 2003.

Demand Response Enabling Technologies Development

Contract #: 500-01-043
Contractor: University of California, Berkeley
Subcontractors: Ron Hofman Company
Contract Amount: $5,500,000
Contractor Project Manager: Gaymond Yee
Commission Contract Manager: David Michel III (916) 651-9864
Status: Active

Project Description:
The purpose of this project is to help develop demand response (DR) enabling technologies in the medium (3-5 years) and long (5-8 years) term by leveraging on-going RD&D funded in communication, information, and control technologies by other agencies (e.g., the Department of Defense at UCB). This contract will focus on specific energy-related tasks that can lead to dramatic decreases (hopefully by a factor of 10) in the installed cost of these technologies for DR applications.

This contract will also focus on DR capabilities that are more powerful and robust than those identified in a baseline study also proposed under the DR Program Plan for funding but with a different contractor. Initially, this contract will attempt to develop DR-related:

- Micro-electromechanical systems (MEMS) sensors and actuators.
- Open-system, mesh-architecture communication systems that can seamlessly share data.
- Real-time distributed-intelligence device networks that are self-organizing.
- Enterprise-wide multi-level control strategies that can absorb legacy systems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing service interruptions through expanded service options and new system-wide capabilities.
- Maximizing market connection by reducing the installed cost of energy-related information, communication, and control technologies.
- Improving the energy cost/value of California's electricity by providing real-time information and a means to automatically respond to supply-side problems.

Proposed Outcomes:

1. Research and develop new reference designs for sensors, meters and thermostats that will make the DR infrastructure very cost-effective and compatible with legacy systems. A project at the University of California, Berkeley, began early in 2003 leveraging existing research funded by the Department of Defense and private industry. Four technologies form the basis of this medium- to long-term R&D. The work has the potential of reducing statewide DR implementation costs by a factor of 10 while at the same time increasing functionality also by a factor of 10.
2. Think through, conceptualize and design a suitable real-time demand response business network for California to facilitate and maximize demand response resources within the State. The *California Demand Response Business Network* project is a collaborative research effort between Utility Integrated Solutions, Dynamic Networks, Nexant, and Savvion. This network, which has been coined as DRBizNet, will be architected using advanced concepts in distributed business network architecture with the goal of enabling real-time collaboration among participants in the DR market in California including customers, utilities, regulators, and service providers (e.g. metering agents, settlement

agents, billing agents, demand exchanges. This projected started in early 2004 and is scheduled to be completed by April 2005.

3. Investigate network security and privacy issues for DR-related communications networks. This third project, which just started, is a collaborative effort between CyberKnowledge and the University of California, Berkeley. In the area of sensor networks, little or no work has been performed regarding security. The research team will identify and categorize security concerns and threats and will propose an architecture with strategies, algorithms, and a roadmap to address them.
4. Specify, design, and develop a software interface that will shield the application software from the hardware platform for ad hoc wireless sensors and actuators, or motes. This fourth project has been approved for funding, but has not started. This project will be a collaborative effort between the Electrical Engineering and Computer Science, Mechanical Engineering, and Architecture departments of the University of California, Berkeley. This interface will permit application portability and facilitate software reuse. Whereas the first project above is looking at the sensor network hardware and reducing its cost, this project is looking more at reducing the cost of software development for sensor network hardware.

Project Status:
The project is active and is well on its way in achieving the project goals.

Demonstration of Intelligent Software Agents for Control & Scheduling of Distributed Generation

Contract #: 500-00-016
Contractor: Alternative Energy Systems Consulting, Inc.
Subcontractors: Infotility Inc.
Contract Amount: $844,970
Match Amount: $48,605
Contractor Project Manager: Gerald Gibson (858) 560-7182
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Active

Project Description:
The purpose of this project is to demonstrate intelligent software agents (Smart*DER technology) for control and scheduling of one or more distributed energy resources (DER) in conjunction with building energy management systems. This will give building managers an integrated and automated solution for demand response or distributed generation dispatch. This software responds to price signals and alerts and can automatically choose between using load reduction strategies, on site generation or a combination of the two to provide the most economic solution to the owners. This software can also bid unused resources into an energy market and can coordinate responses across geographically separate sites through the use of the internet for communication. The software is capable of operation across over 10,000 sites. This project continues research begun under PIER contract number 500-98-040. The goal of the project is to develop the interfaces that allow the software to operate with a large variety of equipment in the marketplace. After the interfaces are developed, a field test with a variety of equipment and various participants will be performed. This field test will provide the necessary data on potential savings to entice customers to use this new technology in their products and operations.

Smart*DER agent technology is an enabling technology that will make it cost effective to have small generation sources and curtailable loads available for dispatch by utilities or the California independent system operator (ISO) for grid support using both pricing schemes and alerts. The software allows the generators or curtailable loads to be unmanned, remotely dispatched, and responsive to price signals and alerts, while retaining their ability to be integrated and used in the daily operations of individual sites.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by enabling a greater participation by owners of distributed energy resources through the use of intelligent software agents to perform demand response for curtailable loads and for control and scheduling of distributed generation. This will reduce distribution system congestion and avoid distribution line losses.

Proposed Outcomes:

1. Demonstrate intelligent software agents successfully controlling and scheduling distributed energy generation resources.

The technical performance objectives of this project are to:

2. Update the Smart*DER product specification based on feedback received during the Phase I effort as well as changes that have occurred in the California energy marketplace.
3. Identify and enlist participation by one or more potential commercialization partners that will integrate Smart*DER into their technology for the field test.

4. Refine Smart*DER technology to reflect changes in the product specification and to provide interfaces with field test participant's software/products.
5. Complete a successful feasibility test assessment of Smart*DER technology scheduling/controlling actual loads and/or distributed generation assets in the "real world" California marketplace.

The economic performance objective of this project is to:

6. Identify and engage one or more partners for continued commercialization of Smart*DER technology.

Project Status:
The project is behind schedule because of the inability of the principal subcontractor, Infotility Inc., to find a demonstration site. The demise of direct access in California has made finding a demonstration site difficult. A regulatory barrier that has inhibited demonstration participation is a lack of an attractive tariff for distributed generation (DG) and Demand Response. The high capital investment costs of acquiring DG coupled with the current high costs of natural gas and the relatively low price of electricity has also greatly limited the purchase of DG equipment. This project demonstrates an enabling technology that crosscuts the PIER program areas of Distributed Generation, Demand Response, and Buildings.

DER Integration Technology Assessment and Development Analyses

Contract #: 500-02-019
Contractor: Navigant Consulting, Inc.
Contract Amount: $894,684
Contractor Project Manager: Robert Shelton (415) 356-7122
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Active

Project Description:
The purpose of this contract is to fund research, development and demonstration projects under the Energy Commission Public Interest Energy Research (PIER) program. The contractor will perform technology, market and consumer-needs assessments for the Distributed Energy Resources Integration (DERI) Research Program in order to develop research priorities and plans, implementation plans and evaluations of the program. The contractor will produce the following:

- Administrative reports.
- Conduct Program Advisory Committee meeting.
- Finalized Metrics Tool.
- Conduct portfolio assessment reports, technology roadmap emerging research assessments and R&D plan.
- DERI implementation plan, RFP development, proposals review reports.
- DERI Annual Program Evaluation, and DERI Annual R&D Program Evaluation report.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity, and improving the reliability/ quality of California's electricity by performing technology, market and consumer-needs assessments for the Distributed Energy Resources Integration Research Program.
- Improving the environment and public health cost/risk of California's electricity by developing research priorities and plans, and by implementing plans and evaluations of the program.

Proposed Outcomes:

1. Organize and host Program Advisory Committee PAC meetings.
2. Write Program Advisory Committee meetings summary and Program Advisory Committee annual report.
3. Complete Developments of draft and final Metrics Tool.
4. Produce Portfolio Analysis Report.
5. Produce Portfolio Mapping Tool.
6. Perform DERI Research Assessment.
7. Produce R & D Roadmap.
8. Produce Revise Annual R&D Program Plan (Plan was produced and now will be revised).
9. Produce DERI Annual R&D program Evaluation Report.

Project Status:
This project is active.

DER Partnership Interconnection and Market Integration

Contract #: 500-02-014 **Work Authorization #:** E2I-WA-100
Contractor: Electricity Innovation Institute
Subcontractors: Electric Power Research Institute (EPRI) : John Nimmons & Associates, Inc. : Madison Energy Consultants, LLC : Energy & Environmental Economics, Inc. : Regulatory Assistance Project
Project Amount: $500,000
Match Amount: $395,000
Contractor Project Manager: Ellen Petrill (650) 855-8939
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Active

Project Description:
Distributed energy resources (DER) have the potential to significantly transform the relationship of utilities and customers, and to introduce a much richer set of tools for providing not only power, but also reliability, security, flexibility and power quality in energy systems. With strong support and incentives, DER could account for a significant portion of total electricity generation in the US by 2020.

Electricity Innovation Institute has initiated the Distributed Energy Resources Public/Private Partnership to assemble key public and private stakeholders to work collaboratively to address barriers facing integration of DER into the market. The stakeholders represent utilities, government (state and federal), regulators, DER equipment manufacturers and developers, and consumers. This partnership will help to overcome some of today's obstacles to greater DER deployment. The result will be a more dynamic and robust electricity system that meets customer needs and a more viable, predictable, and growing market for DER applications.

In 2004, the partnership assisted Southern California Edison (SCE) with the development of a competitive solicitation for DER to defer several distribution upgrade projects. This was accomplished via a collaborative approach between SCE, the DER industry, and DER equipment manufacturers.

The objectives of this Agreement are to:

- Assist SCE through a collaborative process.
- Develop a solicitation for a DER project that could defer several distribution projects where all participants benefit from the process.

This project supports the PIER Program objectives of:

- Improving the Energy Cost/Value of California's Electricity by developing win-win approaches for encouraging distributed energy resources. DER can provide lower cost energy for consumers, and can support the grid to reduce congestion with smaller, more efficient generators which are easier to site than central power plants.
- Providing greater choices for California consumers by encouraging DER market integration that simplifies consumer installations.

Proposed Outcome:

1. Develop a solicitation for SCE to successfully acquire DER projects that will defer distribution system upgrades.

Actual Outcomes:

1. The reliability requirement for "physical assurance" has been made more flexible. Originally, SCE was going to require load reduction or "demand limitation" at all times when the distributed generator is not operating. This would have created real burdens for customers otherwise willing to help the utility. Instead, SCE will limit the requirement to 200 to 400 hours per year, with a daily limitation as well, and will make allowances for customer maintenance outages.
2. DG customers and third-party providers need to know whether it's worth the considerable time and expense it will take to respond to a utility DG solicitation. SCE's starting point was that no price or value would be included in its RFP, and proposals would be considered sealed bids, to take or leave. Based on the collaborating partners' input, SCE will now include a 'market reference price' to guide customers, and will negotiate the final agreement with successful proposers.
3. The Model Agreement to be entered into with successful proposers was originally designed such that the utility would take virtually none of the risk. Collaborative discussions persuaded SCE to rewrite it to share more of the risks, and collaborative participants are satisfied that it meets many of the needs of prospective proposers.

Project Status:

The project final report is in the publication process. Following SCE's solicitation in 2005, an evaluation will be done to determine the effectiveness of the collaborative process in assisting SCE in developing a successful deferment solicitation.

Development of a Real-Time Monitoring/Dynamic Rating System for Overhead Lines

Contract #: 500-98-034
Contractor: Engineering Data Management, Inc.
Subcontractors: Power Line Systems, Inc. : Southwest Research Institute : Electric Power Research Institute (EPRI)
Contract Amount: $499,402
Match Amount: $12,000
Contractor Project Manager: Andrew Stewart (970) 204-4001
Commission Contract Manager: David Chambers (916) 653-7067
Status: Active

Project Description:
The overall objective for the project was to develop a system with sensors for monitoring ground clearances/sags in selected spans on a real-time basis coupled with software to model the clearances/sags in all spans that can provide a real-time rating for the line. The technical performance objectives of this project were to develop a practical, user-friendly and cost effective transmission-line monitoring system with the flexibility and features needed to work with existing and state-of-the-art transmission systems. The goal for the line rating software design was to enable the system to be used by transmission system operators, including utilities and the Independent System Operator (ISO) for three purposes: 1) real-time monitoring/dynamic rating of lines, 2) studies to evaluate the performance of existing lines and to re-rate their capacity, and 3) monitoring the status of clearances/sags in "safety critical" areas.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing a system to reduce power outages caused by sagging lines.
- Improving the energy cost/value of California's electricity by improving the efficiency and power carrying capability of monitored lines and reducing costs of power delivery.
- Improving the environmental and public health costs/risks of California's electricity by reducing the need for new transmission corridors and avoiding fires.
- Improving the safety of California's electricity by monitoring transmission line-to-ground clearance thereby avoiding an electrical shock hazard.

Proposed Outcome:

1. Develop a system with sensors for monitoring ground clearances/sags in selected spans on a real-time basis coupled with software to model the clearances/sags in all spans that can provide a real-time rating for the line.

Actual Outcomes:

1. Successfully completed design, development and analysis of the Saggometer Sensor System.
2. The Saggometer Sensor System performed real-time monitoring and dynamic rating of lines.
3. Developed a real-time rating software module (PLS-CADD).

Project Status:
Project is complete.
Final Report Title: Development of a Real-Time Monitoring/Dynamic Rating System for Overhead Lines
PIER Publication Number: 500-04-003
PIER Web Location: www.energy.ca.gov/reports/2004-04-02_500-04-003.PD

Development/Demonstration of Methodology to Assess Value of DER

Contract #: 500-01-039
Contractor: New Power Technologies
Subcontractors: Optimal Technologies : Cupertino Electric : William Stephenson, Consulting Engineer : Rita Norton and Associates : Silicon Valley Manufacturing Group : Roy Skinner, Consulting Environmental Engineer
Contract Amount: $616,689
Match Amount: $145,166
Contractor Project Manager: Peter Evans (650) 948-4546
Commission Contract Manager: Linda Kelly (916) 654-4815
Status: Active

Project Description:
The purpose of the project is to demonstrate an analytical methodology that can identify where distributed energy resources can provide specific transmission and distribution (T&D) network benefits. This methodology will evaluate multiple aspects of network performance including factors affecting stability and power quality in addition to T&D losses. The project will create a detailed and integrated dataset of a utility network that integrates both transmission and distribution.

Once this dataset is accomplished, the project will introduce dispatched loadsheds and embedded generation to see where these additions optimize or improve system performance. This will be achieved through the use of load flow tools traditionally used only for transmission networks, along with new non-linear optimization technologies that simultaneously consider multiple factors and provide repeatable results analyzing systems with large numbers of elements, as is the case with distribution systems. When these locations have been identified and ranked, a portfolio of specific types of DER projects having specific technical and operational attributes that can measurably improve the performance of the utility system will be identified in both engineering and economic terms.

This project will also provide a financial analysis that will allow comparison of these nonwire options (e.g. DER) to wire options (e.g. expanded T&D lines). Additionally, a set of financial and non-financial incentives to facilitate the development of the projects or programs in the portfolio will be developed.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity system by developing an analytical tool that can identify where DER and other nonwire alternatives can be located to help alleviate power quality and T&D capacity and congestion problems in the State.
- Providing more choices to California consumers by helping overcome the barriers to the deployment of distributed generation.

Proposed Outcomes:

1. Demonstrate an analytical methodology that can identify where distributed energy resources can provide specific T&D network benefits.
2. Create a detailed and integrated dataset of a utility network that integrates both transmission and distribution.

Project Status:
The project Kick-off Meeting was held on September 30, 2002. This project's technical work is complete. The Final Meeting will be held in February of 2005 and the Final Report is expected to be available in March 2005.

Distributed Utility Integration Test "DUIT"

Contract #: 500-01-033
Contractor: Distributed Utility Associates
Subcontractors: Endecon Engineering : Pacific Gas and Electric Company
Contract Amount: $2,049,850
Match Amount: $547,151
Contractor Project Manager: Susan Horgan (925) 447-0604
Commission Contract Manager: David Michel III (916) 651-9864
Status: Active

Project Description:
The purpose of this project is to advance the state-of-the-art of distributed resources integration and give new insights into distributed energy resource grid support issues. The increasing potential of distributed resources in emerging utility markets has focused attention on two critical issues: interconnection of distributed resources with electric distribution systems, and the unknown nature of potential interactions between multiple distribution devices. Interconnection is a critical issue because of the diversity of distributed technologies and the variability of interconnection standards and practices from state to state and utility to utility. Another critical issue is that the potential for interactions between distributed resources in close proximity within a distribution system is not known, simply because not enough operating experience has been gained to date.

This Distributed Utility Integration Test (DUIT) is the next step in assuring the safe, reliable, secure and cost-effective inclusion of distributed resources into the electric systems of the future. By collaborating with DUA, the Commission will advance the state-of-the-art of distributed resources integration and strengthen its leadership role in distributed power. By examining current and emerging technologies and operational concepts to properly integrate diverse distributed resources, this project will give new insights into grid support issues and ultimately suggest innovative system protection design concepts.

The goals and objectives of this project are to provide the following:

- Determine what impact large numbers of Distributed Energy Resources will have on the electrical system.
- Prove the feasibility and the integration of diverse distributed resources in a distribution system.
- Provide a testing ground for observing and measuring the interactions between the distributed technologies on the distribution system.

Achieving these goals and objectives requires full-scale implementation testing and demonstration of distributed generation technologies in an actual utility installation.

This project supports the PIER program objective of:

- Improving the reliability/quality of California's electrical system by advancing distributed generation technologies that will help diversify and strengthen the system.

Proposed Outcomes:

1. Develop a DER procurement process.
2. Develop a test plan.
3. Develop specifications for the test management control system.

4. Design a data acquisition system.
5. Develop software for the test management control system.
6. Perform the engineering necessary to prepare the facility testing.
7. Perform the tests.

Project Status:

- Final DER test list has been submitted.
- The DUIT test plan has been approved.
- The DUIT test facility has been commissioned.
- "Single Unit" anti-islanding tests has been completed and reported.
- "Multiple Unit" anti-islanding testing is progressing

High Temperature, Low Sag Conductor

Contract #: 500-01-025 **Work Authorization #:** E2I-WA-002
Contractor: Electricity Innovation Institute
Project Amount: $100,000
Contractor Project Manager: John Chan (650) 855-2452
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Active

Project Description:
The purpose of this project is to evaluate the performance of selected "high-temperature, low-sag" conductors that are capable of significantly increasing the ampacity of thermally constrained transmission lines without the need for extensive tower redesign. Examples include 3M, Invar, and Gapped conductors, and commercial forms of aluminum steel-supported conductors (ACSS) such as ACSS-TW.

The majority of overhead transmission lines currently use steel-reinforced aluminum conductors (ACSRs). ACSRs can be routinely operated at temperatures up to 100 degrees Celsius (212˚ F) and, during emergencies, at temperatures as high as 150 degrees Celsius (302˚ F). Today, however, power industry deregulation is placing new demands on the delivery system and altering high-voltage transmission network power flow patterns. Consequently, networks are increasingly being forced to support power flows and transfer capacities for which they were never designed.

One approach to addressing this dilemma would involve upgrading the transfer capacity through reconductoring selected network lines. In recent years, conductor manufacturers have produced new, nontraditional conductors capable of operating at temperatures as high as 250 degrees Celsius (482˚F) without violating present electrical clearances to ground and other objects. While these conductors have passed most industry standard tests for performance, utilities are wary of installing these yet unproven technologies without having first gained an insight into their performance in a real-world setting.

The project will provide the participating utilities with information on the operational performance of these new conductors through approximately three years of field trial experience and laboratory tests that will be specified by the project funders. In addition, the project will evaluate the performance of conductor fittings -- including splices and dead-ends -- in both field and laboratory tests.

Further, the project will compile practical "engineering-type" information to aid utilities in designing, specifying, installing, inspecting, and maintaining the conductors. The results will position participating utilities as informed buyers and users of the technology.

Participants will have the benefit of gaining first-hand experience on the installation and operation of "high-temperature, low-sag" transmission conductors. Host utilities will have the "high-temperature, low-sag" transmission conductor installed in their transmission system, benefiting from learning directly about their capability.

This project contributes to the PIER program objective of:

- Improving the reliability/quality of California's electricity by enhancing the capabilities of the State's transmission and distribution system. These cables have the potential of

increasing the current carrying capability of California's existing transmission corridors beyond their original design capabilities.

The objective of this project is to answer questions, such as:

- How do manufacturer claims compare to field and laboratory performance?
- What are the design parameters for these conductors?
- What engineering changes are necessary when replacing existing conductors with these products?
- What is the impact of these conductors on existing tower design?
- What special handling precautions apply?
- How do these conductors age, and what factors influence aging?
- What is the long-term performance of line hardware?
- How do conductor fittings perform under high temperatures over long periods?
- What are the costs of operation and lifetime costs?
- What inspection techniques should be used?
- What engineering guidelines and training materials are required?

Proposed Outcomes:

1. Evaluate the performance of selected "high-temperature, low-sag" conductors that are capable of significantly increasing the ampacity of thermally constrained transmission lines without the need for extensive tower redesign.
2. Provide the participating utilities with information on the operational performance of these new conductors through approximately three years of field trial experience and laboratory tests.
3. Evaluate the performance of conductor fittings -- including splices and dead-ends -- in both field and laboratory tests.
4. Provide a summary and analysis of the field and laboratory results. Present findings to funders at a final project workshop.

Project Status:

The project is behind schedule. Electrical Power Research Institute (EPRI) has had difficulty in finding companies willing to participate and meet the EPRI terms and conditions of the demonstrations. EPRI has updated a schedule of activities for this Tailored Collaborative taking into account the changing cable marketplace. It is expected that the project will be completed by 2008.

Innovative Ratemaking Treatment for DER-Synapse

Contract #: 500-03-011 **Project #:** 4
Contractor: National Renewable Energy Laboratory (NREL)
Subcontractors: SYNAPSE
Project Amount: $175,856
Contractor Project Manager: Holly Thomas (303) 275-3755
Commission Contract Manager: Bernard Treanton (916) 654-4512
Status: Active

Project Description:
The purpose of this project is to develop innovative concepts and methods for ratemaking treatments of Distributed Generation. Developing new approaches to ratemaking is critical in this stage of electric power system review and transformation. Technological and power system innovation requires corresponding regulatory innovation success. This project will permit California, utilities and other interested parties to build upon a solid basis of policy analysis and recommendations. Synapse will develop a framework for understanding the many issues that must be addressed in ratemaking for distributed generation (DG). Synapse will interview key personnel and summarize the primary concerns for various interest groups that include utilities, DG manufacturers, suppliers and regulators. Synapse will develop new concepts in ratemaking and tariffs design and policy recommendations regarding appropriate rate treatment of DG.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing new and equitable ratemaking treatments for DG.
- Improving the reliability/quality of the California's electricity by designing justifiable ratemaking treatment.
- Improving the safety of California's electricity by balancing more equitably costs with loads.

Proposed Outcome:

1. Identify and explain broadly applicable concepts in ratemaking that will promote the cost-effective deployment of DG in both regulated and restructured markets.

Project Status:
This project began March 2004. A kick-off meeting was held in August 2004. This project is on schedule, within budget and a draft final report will be sent in April 2005. Completion of the project and final report are due June 22, 2005.

Modeling and Testing of Effects of Unbalanced Loading on Voltage Regulation-DTE

Contract #: 500-03-011 **Project #:** 2
Contractor: National Renewable Energy Laboratory (NREL)
Subcontractors: DTE
Project Amount: $324,909
Match Amount: $110,012
Contractor Project Manager: Holly Thomas (303) 275-3755
Commission Contract Manager: Bernard Treanton (916) 654-4512
Status: Active

Project Description:
There are numerous problems associated with distributed generation (DG). Distribution circuits and line voltage regulators are designed for radial, one-way flow of power. When DG is connected to the circuit, two-way flows can result. Usually distribution circuits are single-phase load, but most of circuit performance measurement analytical tools are based on balanced three phase loads. The American National Standards Institute (ANSI) Standard C 84.1 voltage limits may be satisfied based on three phase balanced load/impedance analysis, but the voltage at single phase loads may be violated when a DG unit is operating or shutdown.

The purpose of this project is to develop the tools, run simulation, and compare the results with actual field measurement of the voltage profile on a distribution circuit with and without distributed energy resources operating. The distributed generation megavolt-ampere (MVA) size is dependant on the system voltage regulation, location of DG and protections. The only effect on the system voltage is the DG's kilowatt (kW) injection at that point of the distribution circuit. If the DG synchronous machine is allowed to absorb or export volt-amperes reactive (VARs), the voltage can be decreased or increased at that point to allow a larger kW injection and thus a larger MVA sized DG. This project will develop processes, standards and technology to enhance safe integration of DER into the electric power grid.

This project supports the following PIER Program objectives:
- Improving the energy cost/value of California's electricity by reducing grid losses and increase kW injection.
- Improving the reliability/quality of the California's electricity by promoting new technologies to increase the use of DER to support the grid.
- Improving the safety of California's electricity by developing advanced electronic to control DER and Grid interconnection.

Proposed Outcome:
1. Develop processes, standards and technology for the purpose of integrating DER in the electrical distribution system.

Project Status:
The project is active and within budget. It is behind schedule.

This project has not yet started. NREL sent a contract to DTE and is waiting for DTE to approve the contract. This project will be delayed by few months.

Real Time Grid Reliability Management

Contract #: 500-99-013 **Work Authorization #:** UC BOA-20-21
Contractor: Lawrence Berkeley National Laboratory
Project Amount: $224,000
Contractor Project Manager: Merwin Brown (916) 551-1871
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Active

Project Description
The Energy Commission and California Independent System Operator (CAISO) are partnering with the California utilities, Bonneville Power Administration (BPA), and the U.S. Department of Energy in the research, development and testing of a new real-time performance monitoring and data analysis system that collects and analyzes real-time data from will also set the stage for a future "smart" electricity grid that will be able to automatically sense and respond to system emergencies.

The increased need to manage the Western regional electricity grid more actively in real time is in large part a result of the ongoing transition from a system operated by monopoly utilities to a competitive energy market. This transition has confronted system operators with many dramatic changes from past practice including unregulated generation owners and market participants creating high volumes of energy trades over large distances. Markets have replaced utilities in performing the match between generation and demand, adding to the operator's burden of controlling larger areas with revised operational responsibilities and more unpredictable system behavior.

This project is the first phase of a planned three phase effort that is scheduled to be completed in 2006.

This project supports the PIER Program objectives of:

- Improving the reliability, quality, and sufficiency of California's electricity by providing operators with real-time information on the actual status of the transmission system in the Western region so that contingencies that impact system reliability can be avoided.
- Improving the energy cost/value of California's electricity by enabling technologies that will help to reduce costs associated with managing system congestion and reliability contingencies (i.e. line outages, plant outages, etc.) by reducing costly generator re-dispatch, initiating load shedding procedures, etc.

Proposed Outcomes:
The three desired outcomes of this multiyear R&D project are to:

1. To accelerate adoption and foster greater use of new, more accurate, time-synchronized Phasor measurements by CAISO reliability coordinators and control area operators as well as by California and BPA utility transmission dispatchers. This three-year phased project will provide these real-time operators with previously unavailable information on the dynamic stability of the grid, and, in the long run, may provide the basis for the introduction of a new generation of automatic grid controls. A specific research objective is to develop a prototype tool that meets CAISO's specifications, such that, upon completion, it can be transferred to a vendor (selected by CAISO) for implementation as a production-grade operating tool.
2. To provide CAISO operators and California utility and BPA transmission dispatchers with a first-ever, voltage security assessment tool that runs in real time. This will require

research and assessment of improved (faster) simulation methods. A specific research objective is to work closely with CAISO operators to develop a prototype tool that meets their specifications, such that, upon completion, it can be transferred to a vendor (selected by CAISO) for implementation as a production-grade operating tool.

3. To improve the accuracy of the system dynamic load and generator models, data and performance assessment tools used by CAISO operations engineers and planning engineers, as well as those used by their counterparts at the California utilities, to establish safe operating margins. Improved models and a better understanding of the likely impacts of remaining uncertainties in these models will increase the reliability of grid operations by allowing operators to more accurately study system voltage problems and the dynamic stability response of the system to disturbances.

Project Status:
The project is on schedule.

Real Time Ratings for Sacramento Area

Contract #: 500-02-018
Contractor: The Valley Group, Inc.
Subcontractors: Niskayuna Power Consultants : PDC, Inc.
Contract Amount: $392,965
Match Amount: $381,303
Contractor Project Manager: Tapani Seppa (203) 431-0262
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Active

Project Description:
The purpose of this contract is to demonstrate the feasibility of implementing real-time transmission line ratings for a large multi-utility area under normal system conditions, by linking the benefits from real time thermal ratings with simultaneous mitigation of voltage constraints, and by developing ratings forecasting methods.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's Electricity by improving economic dispatch.
- Improving the reliability/quality of California's electricity by mitigating the voltage constraints in the Sacramento Area.

Proposed Outcomes:

1. Develop combined procedures for managing voltage and thermal constraints in the Sacramento area.
2. Develop forecasting algorithms based on real-time thermal ratings for day-ahead dispatch.
3. Complete a cost-benefit study regarding large-scale use of real-time thermal monitoring systems in the Sacramento area.

Project Status:

- All monitoring systems have been installed and tested at Western. All equipment is functioning and data collection has been started.
- Western has decided to purchase the monitoring equipment which will allow continuing data collection in parallel with PG&E.
- SMUD has delayed indefinitely the installation of monitors on their system.
- As a general conclusion, the main contractor has found that a project requiring close cooperation between several utilities (including many departments within each utility) is extremely difficult to manage within allocated budgets and fixed time schedules. Different entities have different priorities, which makes it very difficult or impossible to meet the overall objectives within an established timeline. Therefore timelines for projects such as this need to be very flexible.

Recommendations for future work:

1. Use results from the modified version of IntelliCAT for Windows (ICW) software (which is being developed under CIEE subcontract C-04-09) for WAPA's real time monitoring and make arrangements to transmit this data to CAISO as well.

2. Develop and incorporate algorithms for the Probabilistic Rating Pattern forecasting and short term rating persistence forecasting into ICW software. Short term rating persistence, in particular, could be very useful in support of transient rating calculations.
3. Reevaluate the needs and merits for an area-wide application of combined constraint mitigation methods.

Reflective Energies

Contract #: 500-03-012
Contractor: Reflective Energies
Subcontractors: Power Measurements : Endecon Engineering
Contract Amount: $710,000
Contractor Project Manager: Edan Prabhu (949) 380-4899
Commission Contract Manager: David Michel III (916) 651-9864
Status: Active

Project Description:
The purpose of this project is to provide a program of monitoring, data collection, analysis, and reporting for selected distributed generation (DG) systems chosen for their diversity in relation to generation, the distribution grid, and customer impact concerns. Through this project, information will be disseminated to the Interconnection Workgroup (an industry workgroup), customers, utilities, manufacturers, government and others in the interest of simplifying future interconnections, which will help reduce costs.

The goals of this project are to:

- Characterize the electrical effects of DG on the distribution system.
- Evaluate whether Revised Rule 21 has improved the process of the interconnection of DG to the electrical system.
- Assess the potential for simplifying Rule 21 further to expand the types of different applications eligible for a "simplified interconnection".

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electrical system by determining the power quality and reliability impacts of DG units on the distribution system.
- Improving the energy cost/value of California's electricity by assessing the cost-effectiveness of interconnecting DG units under the new Rule 21 guidelines.

Proposed Outcomes:

1. Develop recommendations for further refinement to Revised Rule 21.
2. Conduct case studies on a minimum of seven different DG installations within California.

Project Status:
The project is currently active.

Sagging Line Mitigator (SLiM) Full Scale Demonstration

Contract #: 500-01-025 **Work Authorization #:** E2I-WA-006
Contractor: Electricity Innovation Institute
Subcontractors: Material Integrity Solutions, Inc.
Project Amount: $83,720
Contractor Project Manager: Rambabu Adapa (650) 855-8988
Commission Contract Manager: David Chambers (916) 653-7067
Status: Active

Project Description:
Excessive transmission line sag is one of the most prevalent causes for limiting line ampacity and has reportedly resulted in numerous power system outages, particularly for lines rating of 230kV (kilovolts) and below. Thermal expansion of the conductor resulting from high ambient temperatures, low winds, and high line current can lead to excessive line sag. Increases in demand, especially on hot summer days, increases the likelihood of excessive sag and the associated reliability issues.

The Sagging Line Mitigator (SLiM) is a new class of transmission line hardware that fixes the problem by reducing excessive line sag at just the right time. Using state-of-the-art materials and a tested and proven concept, SLiM reacts to increasing conductor temperature by decreasing the effective length of conductor in the span. This mitigates the natural thermal expansion experienced by the conductor during high temperature operation. The impact is to decrease line sag during such operations, which depending on construction specifics can cascade through several adjacent spans.

This project will evaluate the performance of the SLiM on an operating transmission line.

The Energy Commission has provided additional funding for this project so that utility representatives from Pacific Gas and Electric, San Diego Gas and Electric and Southern California Edison can also participate.

This project contributes to the PIER program objective of:

- Connecting to near-term market applications by providing utilities with first-hand information on the operational performance of this new transmission line hardware device. Additionally, the results of this project will position participating utilities as informed buyers and users of this new technology.

Proposed Outcomes:

1. This project will provide participating utilities with first-hand information on the operational performance of this new transmission line hardware device. The demonstration is designed for operation during one "hot" season. The length of the trial can be extended, if necessary, with the cooperation of the host utility.
2. The project will also compile practical "engineering-type" information to aid utilities in designing, specifying, installing, inspecting, and maintaining this device. The results of this project will position participating utilities as informed buyers and users of this new technology. This project is a collaborative project with National Grid –UK, BC Hydro, SDG&E, SCE, PG&E, and Public Service of New Mexico.

Project Status:
This project was completed on time and on schedule. The final report is expected to be published March 22, 2005 on the PIER website.

SF Coop DER Regional Solutions Project

Contract #: 500-03-009
Contractor: M.Cubed
Subcontractors: Energy, Environ, Economics
Contract Amount: $595,647
Match Amount: $660,200
Contractor Project Manager: Steve Moss (415) 643-9478
Commission Contract Manager: David Michel III (916) 651-9864
Status: Active

Project Description:
This research will include an investigation of the costs, benefits and cost-effectiveness of Distributed Energy Resources (DER) options to customers, utilities and society, as well as the technical issues uncovered during the process. One major attribute of this study is looking at how DER affects the load profile on a specific PG&E distribution system feeder. The results will be reported appropriately for a number of audiences, including utilities, governments, energy consumers and other stakeholders interested in making informed decisions about DER programs.

For this project, the San Francisco (SF) Co-op, California's first urban cooperative, will provide a unique platform from which to offer and implement innovative, energy-saving and demand shifting, and environmentally friendly DER technologies. This setting provides the opportunity to examine the implications of DER for a full range of energy users (e.g., low to high income, multi-unit and single family residential, small to large commercial industrial) with a variety of energy demand strategies.

This project includes all of the key components of an electric system – generation, transmission, and distribution – and provides for a rich environment in which to investigate DER and related issues.

This project supports the PIER Program objectives of:

- Improving the reliability, quality and sufficiency of California's electricity by objectively assessing the costs and benefits of DER initiatives to relieve congestion on San Francisco's transmission and distribution network.
- Improving the energy cost/value of California's electricity by identifying and testing DG solutions that can help to lower peak demand and minimize the need for new investments in transmission, distribution, and generation facilities.
- Improving the environmental, public health, and safety of California's electricity by encouraging energy conservation, demand response, and the appropriate development of low-impact, environmentally friendly, DG facilities.

Proposed Outcomes:

1. Establish baseline characteristics of the study area distribution system feeders.
2. Identify the location of significant clusters of customers willing to implement DER technologies on PG&E's electricity distribution system.
3. Select distribution feeder for monitoring and data collection where an effect can be 'seen'.
4. Coordinate and facilitate with the California Public Utilities Commission (CPUC), PG&E, City and County of San Francisco, and the Commission and their respective programs to bring to bear their resources and incentives to create a test bed where sufficient amounts of DER can be implemented such that the hypothesis can be tested.

5. Work with customers on those feeders to obtain incentives from the external programs (e.g., CPUC, City and County of San Francisco, etc.) and have the DER technologies installed if they have not already been installed.
6. Issue price signals to residential participants in the CPUC's Dynamic Pricing Program in accordance to that program's rate structure and guidelines as established by the CPUC. In addition, the Contractor will work to implement demand-response programs focusing on businesses.
7. Monitor the effect of the price signals and installed DER technologies on the targeted distribution feeders.

Project Status:

- Baseline characteristics of the study area feeders have been established.
- Significant clusters of customers willing to implement DER technologies on PG&E's electricity distribution system have been identified and enrolled.
- A distribution feeders has been selected for monitoring and data collection and a second feeder is in the process of evaluation.

Universal Interconnect Device-Northern

Contract #: 500-03-011 **Project #:** 3
Contractor: National Renewable Energy Laboratory (NREL)
Subcontractors: Northern Power Systems
Project Amount: $603,664
Match Amount: $327,106
Contractor Project Manager: Holly Thomas (303) 275-3755
Commission Contract Manager: Bernard Treanton (916) 654-4512
Status: Active

Project Description:
The purpose of this project is to develop and test a prototype Advanced Universal Interconnect Device interoperable across distributed generation (DG) technologies with enhanced functionality that will reduce interconnection cost and time. This will be an important step in improving the standardization of distributed energy resources (DER) switch devices. Northern Power System (NPS) will develop the specification for the DER Interface System using input from industry experts in the field of protection relaying and anti-islanding. NPS will also review and model various synchronization methods and use its Digital Signal Processing control hardware software platform. NPS will use its Smart-View Remote Terminal Unit and data management device to collect and store power system data and communicate and share data by internet. The prototype power module will use solid-state switching elements with a 200 amp rating and capacity from a few kilowatts (kW) to several megawatts (MW) for use with NPS power network test bed. NPS will test the DER interface system and connect the 75 kW DER power network test bed to the local utility.

Upon successful testing, a prototype unit will be shipped to NREL for Institute of Electrical and Electronics Engineers (IEEE) 1547 compliance testing.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing and standardizing a new switching gear.
- Improving the reliability/quality of the California's electricity by improving DER reliability to support the grid.
- Improving the safety of California's electricity by developing advanced electronics to control DER and grid interconnection.

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Proposed Outcomes:

1. Develop processes, standards and technology for the purpose of integrating DER in the electrical distribution system.
2. Develop an Advanced Universal Interconnect Device that is compliant to IEEE 1547.

Project Status:
This project is active, on schedule and on budget. The project started September 2004 after the contract was approved by both parties. Northern is making good progress on the DER Prototype Component Design and will maintain the delivery schedule. A preliminary Design Review Meeting is scheduled for February 2, 2005 at Northern Power System.

ESI Projects Completed in 2004

2 kWhr Flywheel Energy Storage System

Contract #: 500-98-036
Contractor: Trinity Flywheel Power Corp
Contract Amount: $1,057,406
Match Amount: $1,062,494
Contractor Project Manager: Melissa Reading (925) 455-7998
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Completed

Project Description:
AFS Trinity Power Corporation has completed its PIER contract in February, 2004 for a Flywheel Energy Power System as documented in final report #500-04-014 titled *Flywheel Energy Storage System*. The overall goal of this project was to identify the key performance elements of an advanced flywheel power system that can perform load following for a distributed generation system. The product demonstrated in this contract is a 100 kilowatt (kW) flywheel power system that delivers power for 15 seconds. Prototypes of this system have been constructed, and tested. As a result of this effort, the key performance elements were identified and demonstrated. The demonstrated system shows good commercial potential, and the results of this project are being used by AFS Trinity to continue with additional development work to make the commercial product more responsive to the marketplace. The company is also seeking new equity investment to complete the steps to a full commercial product launch.

During this contract, AFS Trinity also learned much about the commercial application requirements for this product. The project started in 1998 with the goal of producing an energy storage flywheel that could be used with a residential photovoltaic system for load-shifting energy storage. As the project progressed, AFS Trinity and the Commission realized that this market application had a very low probability of commercial success and decided to shift to a more commercially viable application; that of supporting the increased market penetration of distributed generation systems. The project goal was changed to produce a high power, short duration flywheel power system with applications in distributed generation and power management. Development was then completed for this market application. A successful demonstration of the AFS Trinity flywheel technology to support this application was also completed.

Benefits to California:
The results of the research and demonstrations completed in this project have demonstrated that flywheel power systems can create both economic and environmental benefits for the State of California. Successfully fielded commercial flywheel technology will reduce business losses from power disturbances and increase industrial energy efficiency.

Environmental benefits include air quality improvements and reductions in solid waste generation. As a battery replacement in distributed utility applications, or in the existing commercial UPS market, flywheel technology can directly eliminate environmentally unfriendly batteries systems from the solid waste stream.

With further testing, development and customer acceptance, the AFS Trinity flywheel power system can successfully complete the transition to a commercial product. It serves as an excellent example of the successful collaboration between government and industry.

This project supports the PIER Program objectives of:

- Improving the reliability of California's electricity system by developing a distributed-generation-enabling flywheel energy storage system technology that permits distributed generation technologies to be more easily integrated into the utility grid.
- Reducing environmental risks from California's electric system by providing a more environmentally friendly energy storage technology and enabling the increased use of environmentally responsive renewable distributed generation technologies.

Proposed Outcomes:

1. The technological objectives of this project are to:
   - Produce a 2 kWh Flywheel Motor Generator.
   - Use magnetic bearings instead of ceramic bearings.
2. The performance objectives of the flywheel energy storage system are:
   - Usable storage up to 2 kWh.
   - Maximum output power greater than or equal to 5kW.
   - A rated output of 2kW.
3. The economic objective of this project is to:
   - Have a production cost of $30,000/kWh, or less, for production volumes of one to ten units.

Actual Outcomes:

During this effort, AFS Trinity Power has achieved several significant milestones that have advanced the state of flywheel technology and moved closer to a commercially viable flywheel power system. These achievements were:

1. Achieved the following technological objective:
   - Produce a 420 kWh Flywheel.
   - Integration of active magnetic bearings.
2. Achieved the following performance objectives:
   - Highest energy density and power density of any commercially available flywheel power system.
3. Achieved the following economic objective:
   - Extensive market analysis of flywheel commercialization opportunities.
4. Advanced motor control software that exceeds the capabilities of any known third party product.

Project Status:

This project is completed.
Final Report Title: Flywheel Energy Storage System
PIER Publication Number: 500-04-014
PIER Web Location: www.energy.ca.gov/reports/2004-04-07_500-04-014.PDF

This effort has successfully identified and demonstrated the key performance elements an advanced flywheel power system needs to perform to provide load following for a distributed generation system. As a distributed generation load following device, it will facilitate customer acceptance of fuel cells, microturbines and natural gas combined heat and power systems.
In addition to the distributed generation load following application, AFS Trinity has identified commercialization requirements for three additional applications of its flywheel energy storage systems: power quality, light rail power management and industrial power management. This wider variety of commercial applications identified in this effort will help AFS Trinity and other

emerging flywheel energy storage companies accelerate the commercial acceptance of their products.

Furthermore, AFS Trinity continues to work with several business incubator services in their search for new equity investment that will assist AFS Trinity in launching its flywheel product line. Concurrently with this project, AFS Trinity developed a detailed business plan for the commercialization of this emerging technology.

AFS Trinity recommends the continuation of the product development and market development of this promising technology. The next key technology milestone is to demonstrate the successful operation of the flywheel system at an end user site. AFS Trinity will continue to seek both government agency funding and private investment to achieve that goal.

CERTS Microgrid Amendment

Contract #: 150-99-003 **Project #:** 3
Contractor: Lawrence Berkeley National Laboratory
Subcontractors: Northern Power Systems
Project Amount: $1,115,000
Contractor Project Manager: Joseph Eto (510) 486-7284
Commission Contract Manager: Bernard Treanton (916) 654-4512
Status: Completed

Project Description:
This amendment is follow-on work initiated in the Real Time System Monitoring and Control area of the existing Consortium for Electricity Reliability Technology Solutions (CERTS) contract 150-99-003. The DER Integration Micro-grid element involved technology development and an approach where the significant potential of smaller DER (<100 kilowatt (kW)/unit) to meet customers' and utilities' needs can be best captured by organizing these resources into Microgrids. Microgrids are envisioned as clusters of generators (including heat recovery), storage, and loads that are operated as single controllable systems. Microgrids can operate both connected to and synchronized with the utility distribution grid and in isolation from the utility distribution grid (as an "island"). System conditions, and more importantly, economic factors will dictate the prevailing mode of operation.

The purpose of this project is to create the technologies and control strategies needed to capture the full potential of distributed energy resources to improve the reliability of the California interconnected power system via the Microgrids concept. The objectives include: consideration of control systems, including the sensors and instruments necessary to gather intelligence for real-time power management and dispatch or coordination among distributed generation resources. It also includes improved modeling techniques to better characterize the technologies and their impacts on the distribution (and ultimately the transmission) system. With correct placement and control, it should be possible to increase system reliability, lower the cost of power deliver, improve power quality, and reduce the environmental impacts of producing and transmitting electricity.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity and the reliability, quality and sufficiency of California's electricity by creating the technologies and control strategies needed to capture the full potential of distributed energy resources.
- Improving the environmental, public health, and safety of California's electricity by reducing the environmental impacts of producing and transmitting electricity.

Proposed Outcomes:

1. Improve the energy cost/value of California's electricity by providing a means to automatically respond to supply-side problems.
2. Complete a micro-grid control emulation study and execution of contract with a generator manufacturer.
3. Prepare an RFP to solicit a test facility to evaluate the performances of these controls and related protection.

Actual Outcomes:

1. Completed a micro-grid control emulation study.

2. Prepared an RFP to solicit a test facility to evaluate the performances of these controls and related protection.
3. Evaluated Tecogen's performance to supply a generator (DG) for the micro-grid program.

Project Status:
The project has been completed.
Final Report Title: Planning for California's Future Transmission Grid:
Review of Transmission System, Strategic Benefits, Planning Issues, and Policy Recommendations
PIER Web Location: www.energy.ca.gov/reports/2003-10-23_700-03-009.PDF

CERTS Real Time System Grid Management

Contract #: 150-99-003 **Project #:** 4
Contractor: Lawrence Berkeley National Laboratory
Subcontractors: Electric Power Research Institute, Electric Power Group
Project Amount: $1,105,000
Contractor Project Manager: Joseph Eto (510) 486-7284
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
This is follow-on work initiated in the Real Time System Monitoring and Control area of the existing CERTS Electric System Reliability Enhancements contract. The purpose of the contract is to lay the ground work for a transition in reliability management philosophy from one based on passive readiness (with large, market-inhibiting safety margins), to one based on active anticipation and pre-emptive actions in response to impending emergencies. This project will provide integrated research and technology development that will help produce quicker and more flexible options for meeting the reliability, stability and ancillary service needs of California's electricity consumers.

This project supported the PIER Program objectives of:

- Improving the reliability/quality of California's electricity infrastructure by finding new solutions to ensure and maintain reliable electric service in California's restructured electricity market.
- Improving the energy cost/value of California's electricity by increasing the efficiency and competitiveness of California's restructured electricity market.

Proposed Outcomes:

1. Conduct research in the area of real time system management that will allow California's interconnected power system to operate with a better understanding of actual, ever-changing in real time, reliability limits.
2. Conduct research in the area of real time system management that will contribute to the transformation of the electric grid to an automatic switchable network.

Actual Outcomes:

1. Modified, fabricated, installed, demonstrated, and provided training for advanced prototype tools for real time system operations in close coordination with and through in-kind support from the California Independent System Operator (ISO). The tools included: VAR Management extended to include the full California system, Synchronized Phasor Measurement Post-Disturbance Workstation extended to include data from WAPA and SCE.
2. The infrastructure to allow for California ISO to obtain phasor information in real time also prepared in anticipation of future real-time monitoring applications involving the use of these data.

Project Status:
The tasks under the contract amendment for this project, as outlined above, have all been completed. Additional tasks, funded through separate follow-on amendments to the original contract, are still in progress. Preparation of the final report for this project is pending completion of the overall contract. Technical appendices describing work completed under each task have been prepared. The results of the project are being used (or are expected to be used) by the California ISO, and Energy Commission PIER.

Composite Reinforced Aluminum Conductor (CRAC)

Contract #: 500-00-003
Contractor: W. Brandt Goldsworthy & Associates, Inc.
Contract Amount: $1,100,479
Match Amount: $325,000
Contractor Project Manager: Michael Golden (310) 375-4565
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Cancelled

Project Description:
The purpose of this project was to continue research begun under PIER contract number 500-98-035 with the same contractor. Under the first PIER contract, the contractor successfully completed a $75,000 research effort to determine the feasibility of using a composite reinforced aluminum conductor (CRAC TelePower) in applications dominated by the standard aluminum conductor, steel reinforced (ACSR). This follow-on research was to develop prototype manufacturing technology for CRAC and demonstrate the conductor's performance on a 2,000 foot (nominal) 3-phase span using Southern California Edison's expertise. It was hoped that the new conductor would be capable of higher amp loading for the same cost as ACSR, and would also be able to carry digital and analog signals for communications and conductor diagnostic purposes.

Phase II was evaluating manufacturing process improvement concepts which could have fundamentally affected the CRAC-TelePower conductor price and quality. An example was to review the cost savings made possible with co-mingling the glass/resin material as part of the conductor manufacturing process. Another example was to review the feasibility of individually powder coating the fibers with thermoplastic matrix material at the bushing. This idea, if it had been proven feasible, may have created other clean manufacturing facilities in California that would have been able to supply the worldwide composites industry with a superior material system.

The goal of this project was to design, develop and demonstrate a transmission line with both power and data transmission capability. The project demonstration of this concept also included developing and demonstrating new manufacturing methods needed to make it cost-competitive. This technology could have potentially strengthened California's and the Nation's electric power and communications infrastructure. The research would have also enabled substantial environmental benefits because the technology would have resulted in the ability to reconductor existing lines with a conductor that transfers more power per unit of weight.

This project supported the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by avoiding power outages caused by line sagging and swinging, high winds and ice buildup.
- Improving the energy cost/value of California's electricity by reducing losses and the costs of replacing conductors.
- Improving the environmental and public health costs/risks of California's electricity by reducing the need for new transmission lines and corridors.
- Improving the safety of California's electricity by significantly reducing the potential for line clearance violations.

Proposed Outcomes:

1. Beta-test CRAC manufacturing technology by producing sufficient, specification-grade CRAC-TelePower conductor to span three phases at 2,000 feet in a real-time power transmission demonstration.
2. Demonstrate the CRAC-TelePower combined power and data communication conductor in a 2,000 foot, 3-phase conductor span. Specific performance targets were:
   - Line Sag: Target is 20% less line sag over entire operating temperature range.
   - Ampacity: Target is 40% more "Ampacity" compared to ACSR (DRAKE).
   - Magnetic Fields: Target is 50% reduction in magnetic fields on the ground.
   - Damping: Target is increased damping under conditions of galloping and aeolian vibrations.
   - Data Transfer: At least 0.5°C accuracy with a spatial resolution of one meter (analog).
   - Fewer than 1 error bits per 109 bits (digital).
3. Determine the feasibility of manufacturing "CRAC TelePower" for $1 per product pound.

Project Status:

The project reached the second objective. Unfortunately this contract was terminated in December, 2003 because the contractor was unable to perform the tasks necessary to complete the project. Shortly after the death of Mr. Goldsworthy in 2003, project personnel left the employ of the company and the company entered into bankruptcy proceedings.

DR Online Resources Guide Update

Contract #: 500-02-014 **Work Authorization #:** E2I-WA-110
Contractor: Electricity Innovation Institute
Subcontractors: Energy International, Inc.
Project Amount: $136,100
Contractor Project Manager: Brice Freeman (650) 855-1050
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Completed

Project Description:
The objective of the proposed project is to expand and update the *California Distributed Energy Resources Guide*, an on-line resource located on the California Energy Commission website. The *California Distributed Energy Resources Guide* was initially released in January 2002. Overall, this project will ensure the *Guide* is up to date with current technology and market developments, and will add important information about leading technologies. Also, since the original guide was developed, some emphasis has shifted to new technologies such as combined heat and power (CHP) and Energy Storage. Discussions of these technologies need to be added to or expanded in the *Guide*.

Goals of the Work Authorization:
The goal of this Work Authorization is to provide an update and expansion of the on-line *California Distributed Energy Resources Guide*.

This project supports the PIER Project objectives of:

- Improving the energy cost/value of California's electricity; and improving the reliability/quality of California's electricity by expanding and updating the *California Distributed Energy Resources Guide*.

Proposed Outcomes:

1. Provide DER Equipment and Research Initiatives Section updates and additions with a focus on combined heat and power (CHP).
2. Enhance and expand the Background section, including the development of animated graphics to better describe the various options and benefits of DER to consumers.
3. Revise the Markets and Demonstrations sections.

Project Status:
This project was delayed due to difficulty with the animations. However, this project was completed November 2004, and the Energy Commission website has been updated with these deliverables:

⇒ http://www.energy.ca.gov/distgen/

Electric System Reliability Enhancements

Contract #: 150-99-003 **Project #:** 1
Contractor: Lawrence Berkeley National Laboratory
Subcontractors: Electric Power Research Institute, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratories, Bonneville Power Administration, Southern California Edison, University of Wisconsin, Electric Power Group, Optimal Technologies
Project Amount: $7,200,000
Contractor Project Manager: Joseph Eto (510) 486-7284
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
The purpose of this project is to address the transition of California's electricity supply and delivery infrastructures from vertically integrated, utility-controlled organizations to restructured, market-driven institutions. Power supply, network management and control systems are being driven to find new solutions to the traditional methods used to ensure stable power flows, frequency and voltage control. This project will provide an integrated suite of reliability-related research and technology development that will help produce quicker and more flexible options for meeting the reliability needs of California's electricity consumers in the new industry structure. This project was conducted by Lawrence Berkeley National Laboratory, acting on behalf of the Consortium for Electric Reliability Technology Solutions (CERTS).

This project supported the PIER Program objectives of:

- Improving the reliability/quality of California's electricity infrastructure by finding new solutions to ensure and maintain reliable electric service in California's restructured electricity market.
- Improving the energy cost/value of California's electricity by increasing the efficiency and competitiveness of California's restructured electricity market.

Proposed Outcomes:

1. Identify and define priorities for publicly-funded reliability research needed to ensure and maintain reliability in California's restructured electricity industry.
2. Conduct research in the area of real time system management that will allow California's interconnected power system to operate with a better understanding of actual, ever-changing in real time, reliability limits.
3. Conduct research in the area of integration of distributed resources needed to capture the full potential of distributed resources to maintain or improve the reliability of the California interconnected power system.
4. Conduct research in the area of reliability and markets, and especially demand response, needed to ensure that a fair and transparent market for reliability services will efficiently and reliably serve California energy consumers.

Actual Outcomes:

1. Prepared technical scoping memos and reports, held workshops, and met with stakeholders and Energy Commission staff to support PIER planning for the ESI transmission reliability program.
2. Modified, fabricated, installed, demonstrated, and provided training for advanced prototype tools for real time system operations in close coordination with and through in-

kind support from the California Independent System Operator (ISO). The tools included: VAR Management, Synchronized Phasor Measurement Post-Disturbance Workstation, Advanced Topology Estimator, Short-Term Load Forecaster, Operator Training Simulator, Dynamic Transformer Rating, and Short-Term Market Simulator.

3. Refined concepts, conducted laboratory bench testing, and prepared initial technical specifications for a full-scale demonstration of the CERTS Microgrid, which allows for clusters of distributed energy resources (DER) to operate as an integrated unit, both connected to and isolated from the electricity grid, with a minimum of fast communication between individual generating units. Implemented enhancements to a DER customer adoption modeling tool. Developed a proof-of-concept for an advanced power electronic inverter.
4. Provided technical support for the re-design of California ISO's congestion management system; conducted scoping for a first-ever demonstration of the use loads to provide system spinning reserve; and supported PIER planning for ESI Demand Response program.

Project Status:
The initial tasks under the original contract for this project, as outlined above, have all been completed. Additional tasks, funded through follow-on amendments to the original contract, are still in progress.

Preparation of the final report for this project is pending completion of the overall contract. Technical appendices describing work completed under each task have been prepared. The results of the project are being used (or are expected to be used) by the California ISO, and Energy Commission PIER.

Electric System Seismic Safety & Reliability Study

Contract #: 700-99-002
Contractor: Pacific Gas and Electric Company
Subcontractors: University of California, Berkeley
Contract Amount: $4,600,000
Match Amount: $5,400,000
Contractor Project Manager: Lloyd S. Cluff (415) 973-2791
Commission Contract Manager: David Chambers (916) 653-7067
Status: Completed

Project Description:
The greatest single natural-hazard threat to electric system reliability in California is the likely occurrence of a major urban earthquake. The 1989 Loma Prieta and 1994 Northridge earthquakes, although deadly and destructive events, were only a portent of potential future earthquake effects and should serve as a warning to all aspects of society to increase the state of earthquake readiness. Post-earthquake functioning of utility systems, in particular electric power service, are viewed by emergency responders and society in general as a vital need for rapid response and recovery from a major urban earthquake.

This project will fund "user-driven" research to support the development and rapid application of methods and technologies for reducing earthquake hazards and vulnerability, and improve electric system reliability and safety of electric transmission and distribution systems. This means that the users of the research results, namely utility engineers and operations personnel, initiate the identification of the specific needs for research, approve the scope of the research effort, and monitor the progress of the research to assure that practical, usable results will be obtained.

These results will enable faster post-earthquake restoration of customer service due to less damage and disruption of electric transmission and distribution service caused by future earthquakes, and by more accurate and immediately available post-earthquake information about the state of damage produced by future earthquakes. The results will also be available to be used, as appropriate, by businesses, industry, regulatory agencies, and the general public in the State to reduce earthquake vulnerabilities and respond more effectively to earthquake effects.

PEER (Pacific Earthquake Engineering Research Center) is a consortium of 18 research universities located in California and other western states that has received National Science Foundation support for research in earthquake engineering and related fields. The PG&E-PEER Business and Industry Partnership was formed in 1996 to address, in a user-driven manner, important earthquake issues encountered by electric utilities operating in earthquake-prone regions.

The goal of this applied research program is to improve the earthquake safety and reliability of electric power transmission and distribution in California. The research program was organized by the Joint Management Committee (JMC) to assure that research results would directly address utility needs in preparing for future earthquake occurrences, and that the results could be quickly implemented by utility personnel or their consultants.

This project supports the PIER Program objectives of:

- Improving the safety and reliability/quality of California's electricity by conducting research to enhance the stability of the electric system after major earthquakes.
- Enhancing local and state economies by minimizing the costs associated with power disruptions after a major earthquake.

Proposed Outcomes:

1. Develop technologies and protocols to mitigate the vulnerability of electric systems to damage directly and indirectly caused by earthquakes.
2. Develop assessment techniques to evaluate damage to electric systems caused by earthquakes and assess fiscal impacts due to the loss of electric service to the community.

Actual Outcomes:

Completed 108 projects that addressed the two proposed outcomes. These projects have provided useful results that meet utility needs in the seven topic areas. It is important to also note the integration of the projects to meet the goal of the program, namely to improve utility earthquake performance. The following bullets summarize, in a narrative form, the cumulative connections between the topics that address this goal.

- Topic 1 results (earthquake ground motions) are used as input to Topic 2 (site response) and Topic 3 (permanent ground deformation) studies.
- Topic 1 results are used as input to assess the vulnerability of substation components and interconnected equipment, as well as equipment qualification testing (Topic 4). Severe ground shaking and ground failures are the direct causes of substation damage that can disrupt power transmission to customers.
- Topic 1, 2, and 3 results improve the assessment of building damage (Topic 5) before earthquakes occur to help identify appropriate mitigation and risk management strategies, and immediately following an earthquake (with Topic 7) to aid in emergency response and recovery activities.
- System earthquake risk models (Topic 6) integrate information about hazards (Topics 1, 2, and 3) and building/equipment fragility (Topics 4 and 5) to estimate damage and functionality of the electric transmission and distribution system.

Although the connections among the individual projects are multi-faceted, a broad picture can be seen in the research results that enable utility personnel (and their regulatory counterparts) to have significantly improved information for taking actions regarding earthquake risks. These actions often include retrofitting a vulnerable building that houses office workers, changes in the procurement procedures and requirements for new equipment, upgrading old equipment and improving anchorages in substation yards, and modifying emergency response procedures to take advantage of new information. The customer benefits from these actions following an earthquake in terms of greater electric power reliability, and faster and less expensive recovery of the overall functioning of society. Of course, there will always be some utility system damage due to random failures of components or facilities, vulnerabilities related to aging infrastructure, and unknown or unexpected response of equipment. However, redundant electric system design and the operation skill of utility personnel can make the extent and duration of outages no worse than those of a winter storm.

Project Status:

The project is complete.
Final Report Title: Electric System Seismic Safety and Reliability
Publication Number: CEC-500-2005-007
Publication Date: January 2005
PIER Web Location: www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-007.html

Energy Storage for Transmission or Distribution Applications (#94)

Contract #: 500-02-028 **Project** #16
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $28,400
Contractor Project Manager: Steve Eckroad (650) 855-1066
Commission Contract Manager: David Chambers (916) 653-7067
Status: Completed

Project Description:
EPRI's Energy Storage for Transmission and Distribution Applications Program offers a portfolio of innovative energy storage options to support Transmission and Distribution owners in their objective to lower capital, maintenance, and operating costs of their equipment. This is accomplished by providing credible and timely data on the cost, benefit, performance and technology readiness for energy storage options suitable to peak shaving applications at the high voltage transmission level and the low voltage distribution level. The issue is not if energy storage devices can reduce peak loading on equipment while increasing their use factor, because energy storage devices are doing that function today in specialized non-transmission and distribution applications. Rather, the real issue is how to specify and deploy the proper energy storage option for the re-regulated, restructured utility transmission and distribution industry.

This project is designed to develop and deploy innovative modifications of existing storage options that have the highest value for today's transmission and distribution systems. Project activities include assessments of the economic and technical feasibility of existing and emerging energy storage applications that are best suited to today's re-regulated transmission and distribution utility industry. Proper assessment and application of energy storage technologies that defer new transmission and/or distribution capacity and increase reliability and through-put of existing transmission and/or distribution assets can reduce capital costs and extend life of transmission and/or distribution equipment. This project will provide the information and data necessary to make energy storage decisions. Next, field trials on promising prototype and emerging energy storage options will be performed, followed by fundamental technology development of the most promising energy storage system. Final activities will provide quantified strategic and operational economic benefits (and appropriate new tools) of energy storage systems applied to transmission or distribution systems.

This project supports the PIER Program objective of:

- Improving the reliability, quality, and sufficiency of California's electricity by developing storage option modifications for transmission and distribution systems.

Proposed Outcomes:

1. Create a handbook delineating cost and performance of key energy storage options best suited to transmission or distribution applications such as super-capacitors, advanced batteries, flywheels, and superconducting magnetic energy systems.
2. Perform an assessment of the economic and technical feasibility of existing and emerging energy storage applications best suited for the industry.
3. Conduct field trials on promising prototype and emerging energy storage options for transmission or distribution applications.

Actual Outcomes:

1. Handbook on Energy Storage Technologies for Application at the Transmission and Distribution Level: Technology Status, Lessons Learned, Applications and Economics. EPRI Product ID #1001834.
2. Energy Storage Technology Valuation Primer: Techniques for Financial Modeling. EPRI Product ID #1008810.
3. No Field trials on promising prototype and emerging energy storage options for transmission or distribution applications were conducted.

Project Status:
The project was completed in December 2004.

The results of the project are expected to be used by the utility industry.

Modeling Interconnection Analysis & Planning

Contract #: 500-03-011 **Project #:** 5
Contractor: National Renewable Energy Laboratory (NREL)
Subcontractors: Northern Power Systems
Project Amount: $405,897
Contractor Project Manager: Holly Thomas (303) 275-3755
Commission Contract Manager: Bernard Treanton (916) 654-4512
Status: Cancelled

Project Description:
The purpose of this project is two fold. The first goal is to validate and leverage the work by Northern Power Systems to develop a universal interconnection device. National Renewable Energy Laboratory (NREL) will model their device with computers and evaluate its performance when interconnected to a simulated utility system. By conducting these modeling evaluations, NREL and Northern will be able to identify any unforeseen protection scheme or operational issues prior to developing the prototype. Following the prototype build, NREL will expand planned laboratory tests of the prototype to validate its performance and ensure that it meets national and state interconnection standards. This work is important to understand the electrical impacts of Distributed Energy Resources (DER) on the utility distribution system and the validation of interconnection standards and rules.

The second goal is for NREL to assist PIER in the development of a multi-year program for advanced power electronic interfaces for DER namely the "Advanced Power Electronics Interface (APEI) Initiative." Power electronic interface costs and reliability continue to be a critical path item to the long term cost effectiveness of many DER systems including PV, fuel cells, and micro-turbines. However, power electronics offer an elegant and flexible solution to integrating DER to the utility system due to their programmability, flexible functionality, and controllability enabling such things as power conditioning or providing utility system support of real or reactive power. Because of this flexible functionality, other DER technologies such as engines are looking to power electronics interfaces to enable better, more flexible integration with the utility system. NREL will assist PIER staff in identifying the status of power electronic technology and where public interest R&D opportunities may exist. Working with PIER staff, NREL will then develop a multi-year R&D plan that PIER staff will consider for follow-on projects funding through competitive solicitations administered by NREL. Staff is also actively collaborating with the Department of Energy (DOE) and hope that DOE will jointly fund this new initiative perhaps as soon as FY 05/06.

These activities support goals of the California Energy Action Plan, and the California Distributed Generation Strategic Plan, the PIER 5-Year Investment Plan, and the PIER DER Integration R&D Plan and Technology Roadmap. The goals of these various policy documents and research plans are to use DER technologies to enhance the cost effectiveness, reliability, power quality, security and environmental friendliness of the California and U.S. electric power system.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by developing a universal and cheaper interconnection device.
- Improving the reliability/quality of the California's electricity by promoting new technologies to increase the use of DER to support the reliability of the grid.

- Improving the safety of California's electricity by developing advanced power electronics to controls DER and Grid interconnection.

Proposed Outcomes:

1. Develop processes, standards and technology for the purpose of integrating DER in the electrical distribution system.
2. Perform modeling and validation testing of NPS interconnect device operation in a simulated utility distribution feeder.
3. Develop a Program Plan for a multi-year initiative in Advanced Power Electronics Interface.

Project Status:

The project is active on schedule and on budget. This project will begin January 2005. The deliverable of this project will open the door to a multi-year project, namely the "Advanced Power Electronics Interface (APEI) Initiative."

Modeling Interconnection and Anti-Islanding of DER-Endecon

Contract #: 500-03-011 **Project #:** 1
Contractor: National Renewable Energy Laboratory (NREL)
Subcontractors: Endecon Engineering
Project Amount: $19,256
Contractor Project Manager: Holly Thomas (303) 275-3755
Commission Contract Manager: Bernard Treanton (916) 654-4512
Status: Cancelled

Project Description:
The overall Purpose of this project is to develop and utilize models to understand how DER operates in distribution circuits and to support interconnection standard development in California. The effort will leverage Endecon's work with Distributed Utility Associate to support the DER simulation distribution system at DUIT site in St Ramon. Additionally Endecon will address issue with IEEE 929/UL1741 islanding test procedure for equipment connected to the grid. That issue pertains to what range of value (1.8 to 2.5) of Q should be required for test evaluation. Endecon will develop statistical models describing the mean and variance of Q. This will result in a better understanding of the conditions that promote islanding.

This project supports the following PIER Program objectives:
- Improve energy cost/value of California's electricity.
- Improve the reliability/quality of the California's electricity.
- Improve the safety of California's electricity.

Proposed Outcome:
1. Develop processes, standards and technology for the purpose of integrating DER in the electrical distribution system.

Project Status:
The project was cancelled effective August 30, 2004. Matching funds were unavailable and without them the project could not go forward. Original Contract was $425,153.00. The administrative funding spent on this project was $19,256.00. The funding transferred to new project ("Modeling Interconnection& Analysis and Planning") is $405,897.

Real Time Ratings for Path 15

Contract #: 700-00-006
Contractor: The Valley Group, Inc.
Subcontractors: Niskayuna Power Consultants : PDC, Inc.
Contract Amount: $369,204
Contractor Project Manager: Tapani Seppa (203) 431-0262
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
The purpose of this project is to demonstrate the feasibility of implementing real-time transmission line ratings for Path 15, which is one of the most complex gates in the California transmission system. Path 15 consists of 6 transmission lines located between central and southern California within PG&E's service territory. This project investigates the feasibility of providing real-time transmission line ratings by monitoring the conductor tension and environmental factors for a multiple transmission line path and communicating the real-time data to PG&E and the system operators at the Independent System Operator (ISO). This project is also unique because it provides a calculated real-time rating for the path directly to the system operators, as opposed to previous systems that store data for collection and later analysis. Finally, this project will also identify other possible paths in California that could benefit from real-time thermal ratings.

This project supports the PIER Program objectives of:

- Improving the reliability and quality of California's electricity by increasing power transfer capability on an annual basis through Path 15.
- Improving the energy cost/value of California's electricity by reducing utility expenditures through decreased transmission congestion on Path 15 during peak periods.

Proposed Outcomes:

1. Develop software and procedures to allow an increase of thermal capacity of Path 15.
2. Verify the applicability of such hardware, software and methods for use on other thermally limited paths and single circuits in California.

Actual Outcomes:
The project was successful in demonstrating the feasibility of implementing real-time ratings for Path 15. The monitors were installed and calibrated, the data was collected and analyzed and results benchmarked against predicted outcomes. Based on the success of this project, PG&E has identified additional critical locations for monitoring and has initiated the installation of additional real-time monitors.

Project Status:
All tasks have been successfully completed. The final report has been completed and published.
Final Report Title: Recommendation Regarding Distributed Generation Interconnection Rules
Publication Number: P700-00-006
PIER Web Location: http://www.energy.ca.gov/reports/700-00-006.PDF

Reflective Energies

Contract #: 500-00-013
Contractor: Reflective Energies
Subcontractors: Endecon Engineering : Overdomain
Contract Amount: $1,501,268
Contractor Project Manager: Edan Prabhu (949) 380-4899
Commission Contract Manager: David Michel III (916) 651-9864
Status: Completed

Project Description:
The purpose of this project is to provide a program of monitoring, data collection, analysis, and reporting for selected Distributed Generation (DG) systems chosen for their diversity in relation to generation, the distribution grid, and customer impact concerns. Through this project, information will be disseminated to the Interconnection Workgroup (an industry workgroup), customers, utilities, manufacturers, government and others in the interest of simplifying future interconnections. This simplification will help reduce costs.

This project will also develop the specifications for a separately developed California certification database for DG systems that are certified for certain applications. The certification database will also streamline the interconnection process and is expected to reduce costs. In addition, this project will develop an interconnection guidebook that will help developers and utility customers to understand the requirements and processes associated with interconnection of distributed energy resources in accordance with Rule 21. Finally, this project will provide active participation in the Institute of Electrical and Electronics Engineers (IEEE) P-1547 Interconnection Standard Workgroup. The Contractor will be acting as co-author for the development of key sections of the new standard.

The goals of this project are to:

- Characterize the electrical effects of DG on the distribution system.
- Evaluate whether Revised Rule 21 has improved the process of interconnection of DG to the electrical system.
- Assess the potential for simplifying Rule 21 further to expand the types of different applications eligible for a "simplified interconnection."

This project could potentially reduce the cost on interconnection below what was experienced prior to the Revised Rule 21 by 30 percent for units less than one megawatt (MW) and by 15 percent for units equal to or greater than one MW. The project could also potentially reduce the costs associated with delays in approval and installation of interconnection by more than 20 percent for projects less than one MW.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electrical system by determining the power quality and reliability impacts of DG units on the distribution system.
- Improving the energy cost/value of California's electricity by assessing the cost-effectiveness of interconnecting DG units under the new Rule 21 guidelines.

Proposed Outcomes:

1. Specifications for an electronic interconnection application system.
2. Specifications for a DG-certified equipment database.

3. Recommendations for further refinement to Revised Rule 21.
4. Case studies of up to 12 different DG installations within California.
5. Develop a DG Interconnection Guidebook.
6. Provide technical support for the IEEE P-1547 National Interconnection Standard.

Actual Outcomes:

1. The database specifications have been completed and are being used to develop the online interconnection application system and certified equipment databases that will eventual reside on the Energy Commission's Distributed Energy Resources website.
2. Additionally, thirty-three interconnection workgroup meetings have been supported to further refine Revised Rule 21. Outreach has been initiated to California municipal, cooperative utilities and irrigation districts. Several have adopted near versions of the Revised Rule.
3. Ten distributed energy equipment models have been approved as "Rule 21 Certified" while other equipment models continue to apply.
4. The *California Interconnection Guidebook*: *A Guide to Interconnecting Customer-owned Electric Generation Equipment to the Electric Utility Distribution System Using California's electric Rule 21* has been published (publication number P500-03-083).
5. Meetings of IEEE P-1547 have been attended where the National Interconnection Standard has passed a milestone adoption. With this national standard adoption, the Rule 21 Workgroup has begun revising Rule 21 to reflect the new national standard.
6. Eleven DG units on six sites were monitored for their effects to their distribution systems, their loads, and between themselves. The finding were published in the *DG Interconnection Monitoring: the FOCUS-II Project Final Report* (publication number CEC-500-2005-009).
7. Published a study to measure the benefits of interconnections of distributed generation titled, *Making Better Connections: Cost Effectiveness Report on Interconnnection of Distributed Generation in California Under the Revised Rule 21*(publication number P-500-04-044F).

Project Status:

This project was completed in December, 2004.
Final Report Title: DG Interconnection: The FOCUS-II Project
Publication Number: CEC-500-2005-006
Publication Date: January 2005
PIER Web Address: www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-006.html

Seismic Studies

Contract #: 500-01-025 **Work Authorization #:** E2I-WA-001
Contractor: Electricity Innovation Institute
Project Amount: $20,000
Contractor Project Manager: Ben Damsky (650) 855-2385
Commission Contract Manager: David Chambers (916) 653-7067
Status: Expired term

Project Description:
The purpose of this project is to seismically qualify substation equipment in accordance with the new Institute of Electrical and Electronics Engineers (IEEE) Standard 693, IEEE Recommended Practice for Seismic Design of Substations.

This project is needed to reduce costs by combining resources to qualify the equipment, and to have equipment that is pre-qualified so that facility construction is not delayed due to qualification. It will also qualify equipment that has the most vulnerable configuration so that other equipment variations can be qualified by similarity methods. A consortium of utilities will provide guidance to the project. Testing will be performed at appropriate test facilities as directed by the consortium.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by qualifying substation equipment to meet the IEEE Standard 693.
- Improving the safety of California's electricity by providing utilities access to equipment that has been qualified in accordance with the standard.

Proposed Outcomes:

1. Develop improved seismic procedures for conducting shake-table tests on selected equipment.
2. Verify compliance of selected substation equipment with IEEE Standard 693.
3. Understand deficiencies of the standard for the qualification of transformer bushings and propose improvements.

Actual Outcomes:

1. Ten utilities formed a consortium under the Electric Power Research Institute with the purpose of qualifying substation equipment to IEEE 693.
2. Selected test facility, prioritized order of tests, established equipment support structure specifications, defined vibration test requirements, and determined specifications for electrical equipment and tests.
3. Tested and qualified eight Capacitor Voltage Transformers from two manufacturers, including a 230-kV (kilovolts) porcelain unit, a 500-kV porcelain unit, three types of 230-kV composite units, and three types of 500-kV composite units.
4. A draft report was submitted for Capacitor Voltage Transformer - CVT TEIMF 500CS.
5. Established the groundwork for testing and qualifying disconnect switches. This includes developing a support structure for the 230-kV switches, identifying switch manufacturers willing to participate, and developing an RFP to go to manufacturers.
6. Two models of transformer bushings have been developed that indicate that a more detailed model is needed.

Project Status:
The term of this project has expired. The final report is under review.

ESI Projects Completed in 2003

Development of a Real-Time Monitoring/Dynamic Rating System for Overhead Lines

Contract #: 500-98-034
Contractor: Engineering Data Management, Inc.
Subcontractors: Power Line Systems, Inc. : Southwest Research Institute : EPRI
Contract Amount: $499,402
Match Amount: $12,000
Contractor Project Manager: Andrew Stewart (970) 204-4001
Commission Contract Manager: David Chambers (916) 653-7067
Status: Active

Project Description:
The overall objective for the project was to develop a system with sensors for monitoring ground clearances/sags in selected spans on a real-time basis coupled with software to model the clearances/sags in all spans that can provide a real-time rating for the line. The technical performance objectives of this project were to develop a practical, user-friendly and cost effective transmission-line monitoring system with the flexibility and features needed to work with existing and state-of-the-art transmission systems. The goal for the line rating software design was to enable the system to be used by transmission system operators, including utilities and the Independent System Operator (ISO) for three purposes: 1) real-time monitoring/dynamic rating of lines, 2) studies to evaluate the performance of existing lines and to re-rate their capacity, and 3) monitoring the status of clearances/sags in "safety critical" areas.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing a system to reduce power outages caused by sagging lines.
- Improving the energy cost/value of California's electricity by improving the efficiency and power carrying capability of monitored lines and reducing costs of power delivery.
- Improving the environmental and public health costs/risks of California's electricity by reducing need for new transmission corridors and avoiding fires.
- Improving the safety of California's electricity by monitoring transmission line-to-ground clearance thereby avoiding electrical shock hazard.

Actual Outcomes:

1. Successfully completed design, development and analysis of the Saggometer Sensor System.
2. The Saggometer Sensor System performed real-time monitoring and dynamic rating of lines.
3. Developed a real-time rating software module (PLS-CADD).

Project Status:
The project is active.

Energy Storage for Transmission or Distribution Applications

Contract #: 500-02-028 **Project #:** 2
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $65,000
Contractor Project Manager: Steve Eckroad (650) 855-1066
Commission Contract Manager: David Chambers (916) 653-7067
Status: Completed

Project Description:
EPRI's Energy Storage for Transmission or Distribution Applications Program offers a portfolio of innovative energy storage options to support Transmission or Distribution owners in their objective to lower capital, maintenance, and operating costs of their equipment. This is accomplished by providing credible and timely data on the cost, benefit, performance and technology readiness for energy storage options suitable to peak shaving applications at the high voltage transmission level or the low voltage distribution level. The issue is not if energy storage devices can reduce peak loading on equipment while increasing their use factor, because energy storage devices are doing that function today in specialized non-transmission and distribution applications. Rather, the real issue is how to specify and deploy the proper energy storage option for the re-regulated, restructured utility transmission and distribution industry.

This project is designed to develop and deploy innovative modifications of existing storage options that have the highest value for today's transmission and distribution systems. Project activities include assessments of the economic and technical feasibility of existing and emerging energy storage applications that are best suited to today's re-regulated transmission and distribution utility industry. Proper assessment and application of energy storage technologies that defer new transmission or distribution capacity and increase reliability and through-put of existing transmission or distribution assets can reduce capital costs and extend life of transmission or distribution equipment. This project will provide the information and data necessary to make energy storage decisions. Next, field trials on promising prototype and emerging energy storage options will be performed, followed by fundamental technology development of the most promising energy storage system. Final activities will provide quantified strategic and operational economic benefits (and appropriate new tools) of energy storage systems applied to transmission or distribution systems.

This project supports the PIER Program objectives of:

- Improving the reliability, quality, and sufficiency of California's electricity by developing storage option modifications for transmission and distribution systems.
- Supporting the use of energy storage devices to absorb system overloads and fault currents.
- Using energy storage devices to shave peak loads.

Proposed Outcomes:

1. Assessment of the economic and technical feasibility of existing and emerging energy storage applications best suited for the industry.
2. Handbook delineating cost and performance of key energy storage options best suited to transmission or distribution applications such as super-capacitors, advanced batteries, flywheels, and superconducting magnetic energy systems.
3. Field trials on promising prototype and emerging energy storage options for transmission or distribution applications.

Actual Outcome:

1. Handbook on Energy Storage Technologies for Application at the Transmission and Distribution Level: Technology Status, Lessons Learned, Applications and Economics, EPRI Product ID #1001834.

Project Status:
The project has been completed.

Enterprise Information Security

Contract #: 500-02-028 **Project #:** 1
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $55,000
Contractor Project Manager: Thomas Kropp (650) 855-2751
Commission Contract Manager: Yvonne Nelson (916) 654-4255
Status: Completed

Project Description:
The strategic mission of this project is to enhance the security of our electrical infrastructure against a broad spectrum of evolving threats including cyber and communications attacks. This project collaborates regarding how the electricity infrastructure can be made more secure without compromising the productivity advantages inherent in today's complex, highly interconnected electric networks. This project enables collaborative industry and government information sharing and both short and long term technology development and deployment to address resolution of this dilemma. The electric power industry must quickly rethink its basic approach to system security, identifying the most important vulnerabilities and implementing programs to address the terrorist threat through improved prevention, mitigation, and recovery.
This project supports the PIER Program objective of Improving the reliability and quality of California's electricity by researching issues to assist the electric power industry to identify vulnerabilities and implement programs that will enhance the security of the system.

Proposed Outcomes:
1. Countermeasures development (technologies and methodologies) and testing: The contractor is developing intrusion detection software, high-speed encryption tools, and security-enhanced Inter-Control Center Communication Protocols (ICCP).
2. Risk mitigation/management, quantification and increased awareness: Through collaborative information sharing, the contractor is developing guidelines, best practices, lessons learned, standards, procedures, and contingency mitigation plans.
3. Reduction of vulnerabilities associated with reliance on the Internet: The contractor is investigating the feasibility of eliminating reliance on the internet for critical utility operations and the potential to move toward a new communications infrastructure for secure utility operations.

Actual Outcomes:
1. Inter-Control Center Communication Protocols TASE 2 Security Enhancements, technical report, EPRI Product ID # 1002596.
2. Supervisory Control and Data Acquisition Systems Security Guide, technical report, RPRI Product ID # 1002604.
3. Scoping Study on Security Processes and Impacts, informal technical update, EPRI Product ID # 1008988.
4. Workshop on Energy Information Security topics, EPRI Product ID# E215120.

Project Status:
The project has been completed. The Commission's participation in this project ended as of December 31, 2003.

ESI Projects Completed in 2002

Assessing California Reserve Margins

Contract #: 100-98-001 **Project #:** 52
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: EPRI Solutions
Project Amount: $25,000
Contractor Project Manager: Gary Geschwind (650) 855-2087
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Completed

Project Description:
The purpose of this project is to develop a report summarizing the value of adequate reserve margins for California and the Bay Area, particularly the San Francisco-San Jose corridor.

Part of the PIER Program's responsibility relates to providing a reliable supply of electric power to California ratepayers. It is, therefore, important for the Commission and the California Consumer Power and Conservation Financing Authority (CP&CFA) to understand what risk is associated with any planned or attained reserve margin of generation resources of all types in attempting to ensure adequate reserve margins to supply all the state's electricity needs.

This project will develop information to help answer the question: What is the risk of California electric customers experiencing power outages at varying levels of California generating reserves?

This project supports the PIER Program objective of:

- Improving the Reliability/Quality of California's Electricity by improving understanding of how adequate reserve margins can reduce the frequency, duration, and cost of outages.

Proposed Outcomes:

1. Develop a better understanding of how decentralized electric generation and non-generation options might reduce the frequency and length of outages and customer outage costs.
2. Compare the value of more peaking and customer units to increased reserves.
3. Determine how the options in task 1, above, might provide insurance against spot market price volatility due to the presence of market power at the margin.
4. Identify principal barriers to the implementation of renewable distributed generation in California and the ways the CP&CFA can remove or alleviate these barriers.

Actual Outcomes:
The project team delivered a final report to PIER and the California Power Authority in early 2002. The report describes the value of reserves as insurance in an uncertain world, covers distributed energy resources and distributed generation and their potential role in reducing outages discusses the impact of load management (conservation, real-time pricing, and curtailment) and identifies barriers to the implementation of renewables as well as opportunities for removing those barriers.

Project Status:
The project is complete.

Composite Reinforced Aluminum Conductor (CRAC)

Contract #: 500-00-003
Contractor: W. Brandt Goldsworthy & Associates, Inc.
Contract Amount: $1,100,479
Match Amount: $325,000
Contractor Project Manager: Michael Golden (310) 375-4565
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Cancelled

Project Description:
The purpose of this project is to continue research begun under PIER contract number 500-98-035 with the same contractor. Under the first PIER contract, the contractor successfully completed a $75,000 research effort to determine the feasibility of using a composite reinforced aluminum conductor (CRAC TelePower) in applications dominated by the standard aluminum conductor, steel reinforced (ACSR). This follow-on research will develop prototype manufacturing technology for CRAC and demonstrate the conductor's performance on a 2,000 foot (nominal) 3-phase span using Southern California Edison's expertise. The new conductor has advantages of higher amp loading for the same cost as ACSR, and the potential for carrying digital and analog signals for communications and conductor diagnostic purposes.

Phase II is evaluating manufacturing process improvement concepts which may fundamentally affect the CRAC-TelePower conductor price and quality. An example is to review the cost savings made possible with co-mingling the glass/resin material as part of the conductor manufacturing process. Another example is to review the feasibility of individually powder coating the fibers with thermoplastic matrix material at the bushing. This idea, if proven feasible, has so much merit that it may lead to other clean manufacturing facilities in California that could supply the worldwide composites industry with a superior material system.

The goal of this project is to design, develop and demonstrate a combined transmission line power and data transfer concept. Successful demonstration of this concept also includes developing and demonstrating new manufacturing methods needed to make it cost-competitive. This technology can potentially strengthen California's and the Nation's electric power and communications infrastructure. The research will also enable substantial environmental benefits because the technology will result in the ability to reconductor existing lines with a conductor that transfers more power per unit of weight. Many miles of California's overhead electricity transmission lines have reached the end of their service lives or are being stressed beyond their design limits due to load growth and heavy power transfers across longer distances. This technical development is very timely as the current age of transmission lines ranges from 30–70 years.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by avoiding power outages caused by line sagging and swinging, high winds and ice buildup.
- Improving the energy cost/value of California's electricity by reducing losses and the costs of replacing conductors.
- Improving the environmental and public health costs/risks of California's electricity by reducing the need for new transmission lines and corridors.
- Improving the safety of California's electricity by significantly reducing the potential for line clearance violations.

Proposed Outcomes:

1. Beta-test CRAC manufacturing technology by producing sufficient, specification-grade CRAC-TelePower conductor to span three phases at 2,000 feet in a real-time power transmission demonstration.
2. Demonstrate the CRAC-TelePower combined power and data transfer concept in a 2,000 foot, 3-phase conductor span. Specific performance targets are:
   - Line Sag: Target is 20 % less line sag over entire operating temperature range.
   - Ampacity: Target is 40 % more "Ampacity" compared to ACSR (DRAKE).
   - Magnetic Fields: Target is 50 % reduction in magnetic fields on the ground.
   - Damping: Target is increased damping under conditions of galloping and aeolian vibrations.
   - Data Transfer: At least 0.5°C accuracy with a spatial resolution of one meter (analog).
   - Fewer than 1 error bits per 109 bits (digital).
3. Determine the feasibility of manufacturing "CRACTelePower" for $1 per product pound.

Project Status:

The project reached the second objective. Unfortunately this contract was terminated because the contractor was unable to perform the tasks necessary to complete the project.

Distributed Energy Resources Public Website

Contract #: 100-98-001 **Project #:** 34
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $160,157
Match Amount: $160,157
Contractor Project Manager: Doug Herman (650) 855-1057
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Completed

Project Description:
The purpose of this project was to develop a web site to provide current, reliable information about distributed energy resources (DER) to assist a broad public audience in evaluating and implementing DER.

Distributed energy resources are poised to play a key role in California's energy future. Yet many people—including energy professionals, policy makers and energy consumers—are not knowledgeable about DER technologies and associated issues. This lack of knowledge has presented a barrier to DER implementation and deployment.

To meet the need for accurate and objective information about DER, the PIER Program and EPRI developed the California Distributed Energy Resource Guide. This public benefit website addresses all aspects of DER in a well-organized, easy-to-use structure. The website includes much of the information developed by EPRI's distributed resources program over the past several years. The EPRI program provides unbiased information to help all DER stakeholders to understand DER's role in the evolving energy enterprise. The information is the latest and best available, derived from primary research, original studies, and an extensive network of contacts in the DER industry, energy companies, research organizations, and government.

The site can be accessed from the CEC's home page by clicking the link to Distributed Generation in the right hand links column under "Power Plants & Licensing" or directly at: www.energy.ca.gov/distgen

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing information to support development of generation options that provide peaking power, enhance system reliability, and assure power quality.
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power.
- Improving the environmental and public health costs/risks of California's electricity by providing information to support the development and implementation of fuel cells and other environmentally preferred generation technologies.

Proposed Outcomes:
By providing information to stimulate the development of distributed energy resources, this project will help:

- Reduce the cost of electricity and increase its value.
- Increase the reliability of the electric system.
- Reduce the environmental impacts of electricity generation, distribution and use.

- Enhance California's economy.
- Demonstrate a connection to the market.
- Advance science and technology not provided by competitive and regulated markets.

The DER Public Web will present information that addresses the needs of the public/consumers of California who may be interested in a DER application at their home or business. The site's intended audience also includes equipment vendors, consultants, government agencies, and the research/academic community. Information categories include:

- Background/introduction.
- DER technologies.
- Economics of owning and operating DER technologies.
- Markets and applications for DER in California.
- Electrical interconnection.
- Examples and case studies.
- Policy implications.

Project Status:
The project was completed January 29, 2002. The DER Public Web (www.energy.ca.gov/distgen) offers information of value to anyone interested in DER, whether they are seeking a basic introduction to DER equipment and benefits or more in-depth information on economics, permitting, regulatory activities and policy issues.

Enterprise Information Security (EIS) - Program 86

Contract #: 500-00-023 **Project #:** 52
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $45,000
Match Amount: $1,421,096
Contractor Project Manager: Jim Fortune (650) 855-2500
Commission Contract Manager: Laurie ten Hope (916) 654-4637
Status: Completed

Project Description:
The purpose of this project is to address concerns over the security of the energy industry's electronic infrastructure against cyber threats. These threats range from corporate espionage by competitive rivals to sabotage by hackers or terrorists. Immediate concerns center on the vulnerabilities of electronic operations systems such as supervisory control and data acquisition (SCADA) and plant distributed control systems (DCS) and their interconnectivity with corporate business systems. As the energy industry becomes increasingly automated and electronically connected, a concerted cyber attack could be catastrophic from business, customer and national security perspectives.

This EPRI program identifies and addresses security issues through a series of meetings and workshops that provide forums for sharing information on best practices, lessons learned, and vulnerability assessment results. In addition, the program focuses on the development, application, and testing of technical solutions.

This project supports the PIER Program objective of:

- Improving the reliability of California's electricity by leveraging the collective knowledge of the participants to develop strategies for protecting the State's critical electric power infrastructure against cyber threats.

Proposed Outcomes:

1. Organize and facilitate workshops for collaborative exchange of information and ideas to support the development of robust security programs.
2. Provide security guidelines covering critical security activities and policies and procedures, all reflecting the collective knowledge of the industry.
3. Provide security enhancements that reduce the vulnerability of control centers, SCADA systems, power plant controls, field devices, customer electronic meters, and the protocols used to communicate with these devices, while meeting operational needs.
4. Enhance the risk assessment framework developed in 2001 to help decision makers understand and evaluate the costs and benefits of different security measures.

Actual Outcomes:

1. Workshops
   - Three topical workshops were delivered in 2002.
2. Guidelines, Policies and Procedures
   - EPRI published a report, *Security Vulnerability Self-Assessment Guidelines for the Electric Power Industry* (1001639), that provides detailed guidelines and technical information that will assist any organization engaged in generating, transmitting, distributing, or marketing electric power in performing its own security self-assessment.

3. Security Enhancements
   - EPRI published a report, *ICCP (TASE.2) Security Enhancements: Executive Summary* (1001641) that summarizes the current security enhancements that EPRI is recommending to secure the ICCP. The detailed recommendations are presented in EPRI report 1001642.
   - A technical report, *ICCP (TASE.2) Security Enhancements: Volume 1* (1001642), was published that details the security requirements for the Inter-Control Center Communications Protocol (ICCP-IEC60870-6 TASE.2), also known as TASE.2. Based on these requirements, the report assesses the current ICCP for potential vulnerabilities and recommends solutions.
   - A technical update report, *Security Enhancements for Utility Information Architectures* (1002651) was published. It presents the results of a study conducted to assess the impact on performance of the security measures being proposed for the common protocols used for digital control of power system equipment, and to determine what additional security measures outside the domain of protocols may be needed for complete end-to-end security.
4. Risk Assessment Framework
   - A web-accessible risk assessment framework was completed in 2002.

Project Status:
The project has been completed.

Field Trials of Promising Prototype And/Or Emerging Energy Storage Options for T&D Applications

Contract #: 500-00-023 **Project #:** 53
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $31,111
Contractor Project Manager: Steve Eckroad (650) 855-1066
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Completed

Project Description:
The purpose of this project is to demonstrate promising new energy storage options designed specifically for transmission and distribution (T&D) reliability, peak shaving, and VAR control applications. The project will select final design parameters, perform cost/benefit studies, assist in building unit(s), install independent performance monitoring equipment, analyze operating data, and conduct long-term reliability and operational analyses.

This project supports the PIER Program objective of:

- Improving the reliability/quality and the energy cost/value of California's electricity through innovative energy storage technologies that help increase grid utilization while maintaining system stability.

Proposed Outcome:

1. Reduce capital costs and maximize T&D equipment use factors by deploying energy storage equipment based on credible cost and performance data from field trial demonstrations of candidate energy storage options.

Project Status:
In fall 2002 EPRI and AEP signed a tailored collaboration agreement to demonstrate a 100 kW (500 kW power quality), 750 kWh peak shaving sodium sulfur (NaS) battery. This battery has been successfully installed at an AEP office building near Columbus, Ohio. A two-year test program is planned and will be conducted in follow on activities. The report *Field Trial of AEP Sodium -Sulfur (NAS) Battery Demonstration Project* #1001835 will be delivered in 2003. The 2002 funded portion of the project is completed.

Identifying Opportunities in Distributed Generation

Contract #: 500-00-022 **Project #:** 7
Contractor: Gas Technology Institute
Subcontractors: Primen
Project Amount: $75,000
Match Amount: $1,311,700
Contractor Project Manager: John Kelly (847) 768-0665
Commission Contract Manager: Arthur J. Soinski Ph.D. (916) 654-4674
Status: Completed

Project description:
This Fund provides sponsors with the opportunity to gain familiarity with small-scale generation technologies that are still emerging such as microturbines, fuel cells, energy storage technologies, energy recovery, or web-based dispatch and control technology. Further research, though secondary in focus, will examine already existing internal combustion (IC) engines, and traditional small gas turbine technology. By joining with the other investors in this Fund, investors share the costs and obtain the information at a fraction of the costs that would be incurred if done independently. In addition, investors are offered a cost-effective, low-risk environment in which to explore new business opportunities from information and products developed. All investors further save by leveraging previous GTI investments and research.

The major activities under this project are:

1. Business Opportunities in Aggregating Distributed Generation.
2. Pilot Project Demonstration for Web-based Aggregation and Control System.
3. DG Interactive Guidebook on CD-ROM.
4. Microturbine Performance Assessment Program.
5. Field Demonstration of Combined Microturbine & Desiccant Dehumidification (cogeneration).
6. Under-5-MW internal combustion (IC) Engine case history study – U.S. Sites.

This project supports the PIER objectives of:

- Higher quality, more reliable power.
- Addressing barriers to deployment of distributed generation and renewables.

Proposed outcomes:
The following outcomes and deliverables are anticipated:

1. Field evaluations and technology and test reports of proton exchange membrane (PEM) fuel cells and pre-commercial Ingersoll-Rand microturbines (several fuel cell sites and at least one microturbine site in an anchor investor territory.
2. Market research (Delphi) studies for small fuel cells and microturbines.
3. Business and technology assessments for the top-20 solid oxide fuel cell (SOFC) and PEM fuel cell manufacturers.
4. One-half day workshop at investor site to discuss results of the fuel cell study.
5. PowerPoint presentation summarizing fuel cell study results on CD-ROM.
6. Business and technology assessments for top microturbine manufacturers.
7. PowerPoint presentation summarizing major microturbine study findings.

Actual Outcomes:

1. FCT Solid Oxide Fuel Cell (SOFC) Fuel Cell Field Demonstration.
   - GTI worked with, and supported, the host utility, Memphis Light, Gas & Water (MLGW), to promote the project to the Memphis Botanic Garden (MBG). The MBG has agreed to host the FCT SOFC to power a greenhouse(s) on their grounds.
   - MLGW personnel have worked with MBG personnel to gather preliminary site related information. This information has been discussed with the project team, which consists of representatives from the following organizations.
     - Fuel Cell Technologies, Inc. (Fuel Cell Manufacturer).
     - Gas Technology Institute (Project/Technical Management).
     - MBG (Host Site).
     - MLGW (DGMF Host Utility Representing municipals).
   - A tentative site within the grounds of the MBG has been selected. Specifically, the fuel cell will power the Conservatory Classroom greenhouse and possibly the Volunteer Greenhouse. Some pictures are shown below for reference. Conservatory Classroom.
   - Several potential sites near the Conservatory Classroom Greenhouse and the Volunteer Greenhouse have been discussed. A final location will be selected after a site visit is conducted and additional information is analyzed.
   - GTI, on behalf of the DGMF members, reached agreement with FCT on December 30, 2002 for the actual purchase of the fuel cell system and other related items such as training, shipping, warranty, and start-up services.
   - GTI has prepared and issued for review and comment a "Draft" Host Site Agreement.
2. Proton Exchange Membrane (PEM) Fuel Cell Field Demonstration.
   - GTI prepared and issued a bid package to four SOFC manufacturers. Some interest was expressed verbally, however, no written proposals were received.
   - GTI prepared and submitted to Questar a contingency plan for the fuel cell demonstration project to be done in their service area. This plan will be implemented starting in the first quarter of 2003. Essentially, this plan consists of procuring a Plug Power 5 kW PEM fuel cell and working with Questar to find an application for it.
3. DG Web Advisor.
   - GTI continues to populate the DG web site with pertinent documents and information, such as quarterly reports, meeting and teleconference minutes and others.
   - The links section has been fully populated with a variety of web sites related to the distributed energy area. A news/resources section was added with a variety of good information sources.
   - The remote monitoring web site was updated with more technical information about the equipment.
   - GTI has fine tuned access to the HealthSouth remote monitoring site for the IR microturbine test currently taking place. This data can be accessed through the 2001 DGMF web site.
   - GTI is working with the Plug Power demonstration project team to get remote monitoring capabilities installed at the Challenger Learning Center.
   - Customized reports and graphs of past data, as well as access to real live data from the IR demonstration are now available.

4. Microturbine (MT) Performance Testing Program.
   - The Capstone Performance Test Report was issued in January, 2002.
   - GTI installed and tested the Ingersoll Rand 70 kW microturbine. Several specified tests were conducted and the data recorded for further analysis. Results presented to investors.
   - GTI completed the start up of the new Distributed Energy Test Center in Des Plaines, Illinois. The Turbec unit was installed and tested in the new lab.
   - A variety of tests were performed on the Turbec unit. GTI is working on the final report summarizing the results of these tests and the overall performance of the Turbec microturbine. This final report is scheduled to be distributed to fund members in January, 2003. Overall, the Turbec unit worked very well.
   - GTI has received the Capstone 60 kW microturbine and intends to install and test this unit, in GTI's new lab, during the first quarter of 2003.
   - An agreement was made that the DGMF Microturbine Project will provide cofunding for the testing of the Bowman 80 kW microturbine.
5. DG Strategic Service.

   DG Interactive Guidebook is now on CD-ROM.
   - The following information was issued by Primen:
     - Distributed Energy Updates #31 through #34.
     - Primen Perspective #12: "Absorption Chillers and DE: Combo With Potential."
     - Primen Perspective #13: "Distributed Asset Management: Can DE Deliver?"
     - Primen Perspective #14: "Stationary Fuel Cells: Is the Glass Half Empty or Half Full?"
     - Primen Strategic Report dated September 26, 2002: "Will Demand Response Programs Drive the Market for Distributed Resources?"
     - Primen Strategic Report dated June 26, 2002: "The New Economic Landscape for DE."
     - Primen Perspective #15: "Is Small Profitable Today? An Energy Provider's Perspective."
     - Primen Perspective #16: "Residential Distributed Energy, Will It Expand Beyond the Standby Market?"
     - Primen Perspective #17: "Hanging Tough in a Soft Market."
     - Primen Perspective #18: "New Technology Automobiles – Road to Distributed Energy?"
     - Primen Strategic Report dated December 21, 2002: "Distributed Energy's Move to the Mid-Market Applications and Technologies in the 500 kW to 10 MW Range."

Project Status:
The project has been completed.

Intelligent Software Agents for Control & Scheduling of Distributed Generation

Contract #: 500-98-040
Contractor: Alternative Energy Systems Consulting, Inc.
Subcontractors: Reticular Systems, Inc.
Contract Amount: $554,010
Match Amount: $59,543
Contractor Project Manager: Gerald Gibson (858) 560-7182
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Completed

Project Description:
The purpose of this initial phase of this project was to develop a demonstration package of intelligent software agents for control and scheduling of distributed generation. The California Alliance for Distributed Energy Resources (CADER) projects that distributed generation could supply 20 – 40 percent of the estimated capacity that will be needed in California to both replace retired generating plants and to meet increased loads. At its most basic level, an intelligent agent is a software-based device that acts on behalf of the user.

Software agents have a number of capabilities including the ability to monitor their own execution environment, communicate with other agents or the user and maintain some representation of their own internal mental state. Software agents are characterized by their ability to operate autonomously. This means that after an agent starts executing, no further interventions are required from the user. An autonomous agent is able to complete its task on its own. Software agents can be used in a wide variety of applications. An intelligent software agent can contain significant amounts of expertise and can be applied in systems requiring planning or learning capabilities.

Agents are particularly useful in applications involving machine to machine or man to machine communications. One popular use of agents is information seeking and cataloging on the Internet. Agents can be used in applications where they learn about an individual user and modify their own behavior to suit the information-seeking needs of the user. Agents are also useful in applications where multiple agents can communicate and cooperate with other agents for solving a given problem. These agents can be physically located on the same computer or distributed in a variety of locations. Multiple agents operating in conjunction, as an agency, can achieve goals/objectives that would not be otherwise achievable by a single agent.

Use of intelligent software agents with their ability to communicate and collaborate thus distributing the decision process, is well-suited to the task of scheduling and coordinating the activities of large numbers of DER assets. Use of agents in this fashion reduces the level of expertise needed to own and operate distributed energy resources, which in turn, allows greater participation by owners of distributed energy resources in California's competitive energy industry.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by enabling a greater participation by owners of distributed energy resources through the use of intelligent software agents for control and scheduling of distributed generation. Further, the research results will reduce distribution system congestion and avoid distribution line losses.

Proposed Outcome:

1. Develop and test a demonstration package of intelligent agents that communicate and collaborate to schedule operation of distributed energy resources in the California energy market.

Actual Outcome:

1. AESC produced a software package of intelligent software agents virtually controlling and scheduling distributed energy resources and fully participating in all California market activities.

Project Status:

This project has been completed and has met all of its objectives. The PIER Program is currently supporting the next project phase with the awarding of contract 500-00-016.

Overhead Transmission: Overhead Transmission Line Reference Manual - Program 35

Contract #: 500-00-023 **Project #:** 46
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $21,538
Match Amount: $247,683
Contractor Project Manager: Raymond Lings (650) 855-2177
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Completed

Project Description:
The purpose of this project is to revise EPRI's "Red Book"—the *Transmission Line Reference Book: 345 kV and Above.* The revision will update the handbook to incorporate the latest operating experiences and technologies, and to ensure that the handbook reflects both domestic and international operating practices and work environments. The revision will add new chapters as appropriate.

The *Transmission Line Reference Book: 345 kV and Above* is recognized worldwide as the leading handbook—the industry standard— on transmission line design. The printed book has a red cover, and has become widely known as the "Red Book" in the industry. The first edition was published in 1975, the second edition in 1982, and the second revised edition in 1987. It has not been revised since then.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity through updating of the premier guide to transmission line design.

Proposed Outcome:

1. Rewrite and update the book as necessary to incorporate the latest operating experiences and technologies, and to ensure that the handbook reflects both domestic and international operating practices and work environments.

Actual Outcomes:

1. The actual re-write of chapters has started. 40% of the book was re-written in 2002 and the rest will be rewritten in 2003.
2. In August 2002, the various team members met to review progress and to debate face-to-face the structure of various chapters. An advanced draft of the chapter on Electromagnetics was presented, along with a number of "applets"—small software routines designed to demonstrate concepts within the book. Chapter outlines covering Lightning, Live Working, Radio Noise, Audible Noise, Corona Fundamentals and Corona Loss were presented and debated.
3. The editorial panel was formed and met in August.
4. A report was published entitled *Updating the EPRI Transmission Line Reference Book (Red Book)—2002 Progress Report* (1001762), which summarizes progress to date.
5. Additional contracts will be placed for work to start in early January 2003.
6. In January 2003, a review meeting will be held. At that meeting, draft chapters will be presented on Lightning Performance, Corona Phenomena, Radio Noise, and Audible Noise.
7. An Interim Report was published in late 2002.

Project Status:
The project has been completed.

Sagging Line Mitigator (SLiM)

Contract #: 500-98-042
Contractor: Material Integrity Solutions, Inc.
Subcontractors: Power Technology Consultants, LLC : Dariush Shirmohammadi, Ph.D. : Expert Power Engineering Consultant
Contract Amount: $900,000
Match Amount: $303,920
Contractor Project Manager: Manuchehr Shirmohamadi (510) 594-0300
Commission Contract Manager: David Chambers (916) 653-7067
Status: Completed

Project Description:
The purpose of the SLiM project is to develop and test a sagging line mitigator to automatically counteract the sagging of high voltage transmission lines due to high ambient temperature and current flows. The product to be developed has the potential to revolutionize the treatment of sagging overhead transmission lines, instead of retrofitting existing lines or the construction of new lines. SLiM will significantly reduce the risk of forest fires and brownouts caused by sagging lines, increase the efficiency of energy transfer, delay the need for additional line capacity and delay the construction of new lines. Used on new lines, this product will allow reduced tower height and/or increased distance between towers.

This project supports the PIER Program objectives of:

- Improved reliability and quality of California's electricity system by reducing the risk of brownouts (the curtailment of electric deliveries due to line constraints) and power supply interruptions.
- Improved safety of California's electricity by significantly reducing the risk of electrocution and fires caused by sagging transmission and distribution lines.
- Reduced environmental and public health risks/costs of California's electricity system by avoiding the need to build additional transmission towers.

Actual Outcomes:

1. Successfully completed design, development and analysis work for the SLIM device.
2. Conducted successful rigorous prototype testing for applicability proof of concept and design refinements.
3. Develop manufacturing plans for the SLIM device.

Project Status:
The project has been completed. The final report tracking number is "P500-02-074F" and has been published at the following address: http://pier.saic.com/PDF/P500-02-074F.pdf

Transmission & Substation Asset Utilization - Program 38

Contract #: 500-00-023 **Project #:** 47 - 49
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Siemens Power Transmission & Distribution
Project Amount: $78,518
Match Amount: $191,029
Contractor Project Manager: Aty Edris (650) 855-2311
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
This purpose of this project is to demonstrate an advanced controller technology with the potential—if it were applied—to substantially increase power transfer capability on the transmission grid in California and the western region. The Convertible Static Compensator (CSC) is the latest FACTS (Flexible Alternating Current Transmission System) Controller developed under EPRI's FACTS technology development and application program. The CSC is an innovative power electronics-based controller that provides multiple compensating modes, which are needed to securely increase power transfer capability limits of existing transmission systems. The Controller provides flexible dynamic voltage control (to avoid voltage instability), as well as simultaneous real and reactive power flow control on multiple transmission corridors (without risk of transient or dynamic instability). The CSC offers this flexibility by allowing its converters to be connected in shunt, in series, in shunt/series, or in series/series with two lines.

This EPRI project supports demonstration of the world's first CSC—two 100-MVA Voltage Source Converters—which has been installed and is in operation at New York Power Authority's (NYPA's) Marcy Substation in Utica, New York. The CSC is enabling NYPA to mine 240 more MW of power from the grid precisely when they need it most—during contingency situations. Membership in this project provides the Energy Commission with key technical information on installation and operation of the CSC, and integration of the CSC in a power grid.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system.
- Improving the safety/reliability of California's electricity system by developing technologies to maintain and enhance system security in the face of increasing traffic and congestion, while avoiding the environmental impacts associated with new transmission lines and corridors.

Proposed Outcomes:

1. Install CSC voltage source converters for shunt and series compensation.
2. Conduct initial field tests.
3. Deliver industry updates on FACTS and FACTS-related activities.
4. Provide practical guidelines to identify potential transmission bottlenecks, identify measurement locations, perform data analysis to determine line performance under adverse conditions, update/revise static ratings, and (if appropriate) implement quasi-dynamic ratings for lines that do not require installing permanent real-time dynamic thermal circuit rating tools.

Actual Outcomes:

1. Convertible Static Compensator:
   - Phase 1 of the project, shunt operation modes providing + Mvar reactive support at the Marcy substation, is complete. The CSC in shunt operation modes is in service.
   - Record and analysis of the CSC operating performance is an ongoing process.
   - Phase 2 of the project, which includes installation of two series transformers and six bypass switches, is in progress.
   - Commissioning tests of the series operation modes are scheduled for January 2003.
2. Information Sharing and Technology Updates.
   - A website named eprifacts.com is currently under development. The website is structured to provide: background information, tutorial information on the FACTS technology concept, benefits assessment, description of the installed FACTS controllers, articles, and what's new/news and announcements.
   - Work is under way to add a link for web-based simulation tool, a three-area transmission network allowing simulation of STATCOM, SSC, and/or UPFC at arbitrary location with different ratings.
   - The 5th FACTS User's Group meeting was held on October 23-25, 2002 in San Diego, CA. A CD-ROM documenting all presentations is available.
3. Identify Transmission Throughput Bottlenecks.
   - A technical progress report—*Quasi-Dynamic Rating Pilot Study* (1001830)—was published.
   - EPRI Solutions has collected the DTCR data from LIPA-Long Island Power Authority, which was used for developing the methodology for Quasi-Dynamic Ratings.
   - This project was reviewed at the last IPF Task Force meeting, August 8-9, 2002 in Minneapolis, MN and will be reviewed again at the next IPF Task Force Meeting, January 16-17, 2003, in Atlanta.

Project Status:

Commission participation in these EPRI projects has been completed.

ESI Projects Completed in 2001

Airports and Other Complex Intermodel Systems

Contract #: 500-00-023 **Project #:** 9 & 44
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $47,498
Match Amount: $199,700
Contractor Project Manager: Andra Michel (650) 855-2101
Commission Contract Manager: McKinley Addy (916) 657-0833
Status: Completed

Project Description:
The purpose of this two-year project is to evaluate and develop new environmental and energy technologies, and to apply existing technologies—such as electric vehicles—to airport infrastructure to reduce pollution and subsequent costs. Aviation is a key sector of California's economy, with important consumer, energy, and air quality impacts. California's largest airports contribute hundred of millions dollars every year to local and regional economies. However, airports face challenges, including the need to reduce pollutant emissions and control operating costs.

Converting ground transportation and other airport equipment to electricity is one solution to these issues. The electrification of airport gates and the use of electric ground support equipment (GSE) and alternative fuel vehicles have been identified as effective emission reduction compliance measures. These measures promote the public good of cleaner air. Additionally, the use of electric GSE offers energy efficiency and operating cost reduction benefits to airports and California's consumers. These benefits foster the achievement of high-priority public policy goals.

However, the increased use of high and variable frequency electric GSE at airports could adversely affect the quality and reliability of airport electric power systems. As a result, the potential impact of electric GSE and other electrification on power system quality must be understood if California airports are to comply with air quality requirements without compromising airport power quality. EPRI's Airport Solutions Target has developed the necessary methodologies and models to assess the feasibility of electrification and the associated economic, environmental, and power quality impacts on an airport-specific basis.

This project supports the PIER Program objectives of:

- Improving the energy cost/value of California's electricity by providing information on efficiency improvements available for use by airports.
- Improving the environmental and public health costs/risks of California's electricity by reducing emissions from the internal combustion engines used by airport facilities by replacing them with electrically-powered equipment.

Proposed Outcomes:

1. Provide key technical and economic information on electrification of GSE and other airport equipment and use of alternative fuel vehicles—including information on new technology development, environmental impacts, power quality issues, application planning and experience, and market penetration.
2. Conduct a Tailored Collaboration entitled Power Quality Impacts of Airport GSE Charging Systems (TC-51441-001-28325). This project will study the existing GSE charging systems at five airports (including four in California) to document the power

quality characteristics of the systems and assess their impacts on the primary and secondary electric distribution systems that supply power to the airports and gate areas.

Actual Outcomes:
Technical and Economic Information.

1. EPRI organized a national Electric GSE Market Penetration Issues Round Table Meeting in Washington, DC. The meeting was designed to bring together representatives from airports, airlines, vehicle and component manufacturers, government agencies, standards-making bodies, and utilities to address key issues. The meeting, which was scheduled for September 12, 2001, was cancelled due to the terrorist attacks. However, the nine presentations scheduled to be delivered at the meeting were compiled in a proceedings titled *EPRI Electric GSE Market Penetration Issues Round Table Proceedings: September 2001* (1006002) and delivered to all members. The presentations contain vital information on new technology development, application experience, and power quality issues. A conference call, led by Robert Graham, was open to all Electric GSE Market penetration issues round table meeting members followed the proceedings.
2. A fact sheet—*American Airlines Installs Fast Charging at DFW Airport* (1006011) —was published on one airline's experience with fast charging technology for GSE electrification.
3. EPRI hosted two national workshops of the Electric Bus User Group. These workshops were held on April 16-17, 2001 in Tempe, AZ, and on October 9-10, 2001 in Denver, CO. The events offered participants information on new technologies, energy storage and charging issues, and application experience. The proceedings, titled *Electric Bus Users Group Workshop Proceedings: April 2001* (1006158) and *Electric Bus Users Group Workshop: Proceedings: October 2001,* (1006643), were published.
4. A conference call meeting of the Airport Solutions Target Funders was held on November 19, 2001. Minutes of the meeting are available.

Project Status:
The project has been completed.

Demonstration and Evaluation of Emerging Distributed Energy Technologies

Contract #: 100-98-001 **Project #:** 35
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: San Diego Gas and Electric Company : VFL Technologies, Inc.
Project Amount: $15,000
Contractor Project Manager: Brice Freeman (650) 855-1050
Commission Contract Manager: Laurie ten Hope (916) 654-4637
Status: Completed

Project Description:
The purpose of this project is to obtain information on the performance and operational aspects of technologies targeted for distributed energy resources (DER) applications.

DER refers to the concept of deploying small power generation systems throughout electric distribution and transmission systems. DER technologies, including small generators and energy storage devices located near customer loads, offer considerable promise for California's electric power system. For example, DER could help reduce demand on the state's power grid, improve power quality and reliability, and increase the use of environmentally clean energy.

DER technologies are still relatively new and very little real-world information is available regarding DER-related cost, performance, maintenance and interface issues. To help fill the information gaps, the project team collaborated with six companies including the host, San Diego Gas and Electric (SDG&E), to install, interconnect, and test the DER systems at their facilities to monitor and evaluate performance and cost.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing information to support deployment of distributed energy resources to provide peaking power, enhance system reliability, and assure power quality.
- Improving the energy cost/value of California's electricity by assisting in the development/deployment of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power.
- Improving the environmental and public health costs/risks of California's electricity by providing information to support the development and implementation of environmentally preferred distributed generation.

Proposed Outcomes:

1. Obtain first-hand information on the performance and economic aspects of technologies targeted for DER applications.
2. Demonstrate and report on the field operation of a utility distribution system support DER system.
3. Report the performance, cost, and permitting issues of installing DER systems located at end-user facilities and connected in parallel to the utility electric distribution system.
4. Help utilities and end-user hosts gain a better understanding of potential impacts on their electric distribution systems as well as information on performance, emissions, economics, and institutional issues of DER systems, which were unclear at the start of this program.

Actual Outcomes:
This project conducted a field demonstration of DER systems at end-user host sites and a mobile interconnection trailer with a solid-state controller and protection device for utility distribution system support. The project team evaluated two different types of microturbine systems, an advanced internal combustion engine, and a flywheel energy storage system in the end-user demonstration. This program's focus was to gain first-hand experience with the intricacies of integrating DER systems with end-user facilities at the electric bus panel and parallel to the electric distribution circuit.

Project results are presented in an EPRI report, *Demonstration and Evaluation of Emerging Distributed Energy Technologies* (1007043) published in July 2002. The report describes performance, costs, and institutional issues related to deploying DER systems at end-user sites. Although the results highlight the demonstration of DER systems in San Diego, they are applicable to similar installations throughout the United States.

Project Status:
The project has been completed.

Distributed Resources: Information for Business Strategies - Target 34

Contract #: 500-00-023 **Project #:** 10 - 14
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Arthur D. Little, Inc. : EPRIsolutions : Resource Dynamics Corporation
Project Amount: $271,524
Contractor Project Manager: Dan Rastler (650) 855-2521
Commission Contract Manager: Jairam Gopal (916) 654-4880
Status: Completed

Project Description:
The purpose of this project is to provide the Commission with information and tools to enable California ratepayers and energy providers to realize the full potential of distributed resources (DR)-based business strategies. EPRI involvement in DR research provides the unique access and intelligence necessary to identify new markets niches, improve the use of generation and T&D assets, and evaluate DR-based solutions for commercial and industrial ratepayers and business opportunities for energy providers. The target focuses on creating integrated, dependable, packaged solutions and providing information to better understand the DR market, both locally and globally. This EPRI target provides information to support the planning and deployment of DR projects, analyze DR for retail business applications, understand the impacts of DR on utility distribution systems, and evaluate the integration, management, and control of DR technologies.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers.
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power.
- Improving the environmental and public health costs/risks of California's electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

1. Provide strategic information on the DR business environment, trends, technologies, customers, and markets.
2. Compile detailed information to allow analysis of DR for retail business applications.
3. Provide information to assist distribution planners in integrating DR in utility electric distribution systems.
4. Supply information, methodology, and tools to support analysis of DR impacts on electric distribution systems.
5. Conduct market research and provide information on DR markets.
6. Conduct a Tailored Collaboration entitled "Tests and Evaluation of Four Newly Commercialized Distributed Generators in San Diego, CA."
7. Conduct a Tailored Collaboration entitled "Distributed Energy Resources Public Web."

Actual Outcomes:

1. Strategic Information.
   - A quarterly newsletter—Strategic Intelligence Update: DR Business Developments—was published on DR applications, business developments, partnerships, demonstrations, regulatory policy, and electrical interconnection and integration research.
   - An online version of EPRI Distributed Resources Technical Assessment Guide (DR-TAG) was made available. The web-based Guide includes information on product configurations, technology status, development issues, and prospects for future improvements.
   - Educational tech briefs were published on key DR topics.
   - The 2nd Annual Business Venture Forum, an annual national workshop, was held July 25-26 in San Francisco. It provided a forum for utilities, energy companies, equipment manufacturers, and vendors to discuss the latest technology, market, and policy developments.
   - Advisory Group Meetings were held in February, July, and October.
2. Retail Business Strategies.
   - A report—Managing Price Risk with Distributed Resources (1003972)—was published on the potential value of DR as a hedging device for end-use customers.
   - A report—Framework for Evaluating DR Business Cases (1003971)—was published on a decision-making framework for analyzing DR-based business opportunities in the context of a retail portfolio, or as a business unit targeting a defined set of customers with identified needs.
3. Integration of DR in Distribution Systems.
   - A report—Technical Assessment and Evaluation of DR Micro-Grids (1003973)—was published on the technical and economic feasibility of designing and operating micro-grids.
   - A software tool—Distributed Resources Integration Assistant: Version 1.0 (1006540)—was developed to provide useful engineering information, calculators, and screening tools to assist those involved with properly integrating DR into the electric power system.
4. DR Impacts on Distribution Systems.
   - A report—DR Cost Impacts on Transmission and Distribution Systems (1003975)—was published to assess the economic pros and cons of employing DR technologies when T&D system upgrades are needed.
   - A report—Siting of DR Units: Process and Issues (1003974)—was published on the issues and principles involved in the DR siting process and outlines how most tasks can be conducted.
5. Market Research.
   - A report—Market Research in Residential DR Technologies (1003976)—was published on results of primary research into issues facing DR in residential markets with a special emphasis on California markets as leaders in accommodating their behaviors to volatile energy markets.
   - A report—DR Adoption Experience in the Commercial Sector (1003977)—was published on commercial businesses' experience in using DR technologies and the extent to which these technologies met the economic and operations experience of these early adopters.
6. Tailored Collaboration—Evaluation of Five Distributed Generators.
   - A demonstration project was conducted, siting new DER products at end-user facilities with the purpose of collecting end-user experiences and better

understanding the steps required to site DER devices. A full complement of performance, emission, power quality, and noise tests were also conducted. The final report is due in January 2002.

7. Tailored Collaboration—DER Public Web.
   - A website containing nearly all the information generated by the EPRI DR targets in the last three years was made available in a well-organized, easy-to-use structure.

Project Status:
The project has been completed.

Emerging Distributed Resource Technologies - Target 33

Contract #: 500-00-023 **Project #:** 2 - 8
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Gas Research Institute : Nexant, Inc. : Energy International, Inc. : ADI Thermal Power Corporation : American Electric Power : PowerCo US, Inc. : Arthur D. Little, Inc. : National Rural Electric Cooperative Association : Power Computing Systems : Rolls-Royce, Inc. : Southern California Edison : EPRI PEAC Corporation
Project Amount: $461,251
Match Amount: $3,782,757
Contractor Project Manager: Dan Rastler (650) 855-2521
Commission Contract Manager: Jairam Gopal (916) 654-4880
Status: Completed

Project Description:
The purpose of this project is to promote the potential that distributed resources (DR) have to provide a substantial portion of the energy alternatives now demanded by California electricity users. Both energy service providers and customers need accurate and unbiased information on the benefits and liabilities associated with commercially available and emerging distributed resource technologies. DR technologies offer third-party energy service providers and energy customers innovative solutions to their energy service needs. EPRI's Emerging DR Technologies target provides detailed information on commercially mature reciprocating engines and gas turbines, and emerging microturbines and fuel cell systems technologies. To gather this information, EPRI assesses advanced DR components, performs technology validations, and leads pre-commercial development of technologies that offer high pay-off. As a member, the Energy Commission will obtain intelligence in three distinct areas: rapid changes in technology, development of new distributed resources, and post-R&D commercialization initiatives. This target examines a balanced portfolio of near, intermediate, and long-term options.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers.
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power.
- Improving the environmental and public health costs/risks of California's electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

1. Provide unbiased accurate information on emerging DR technologies to increase customer choice and enable competition.
2. Provide methods and guidelines for comparing and testing technologies to improve evaluation of emerging DR technologies.
3. Accelerate development and application of advanced engines for power generation and T&D support through monitoring of technology development and benchmarking of new products.
4. Support application of small gas turbine technology (1-10 MW) by documenting existing installations.

5. Accelerate the development of microturbine technologies by documenting the performance of current and emerging microturbines.
6. Bring to market readiness fuel cell technologies that include polymer electrolyte membrane (PEM) fuel cell systems and ultra-high efficient solid oxide fuel cells (SOFC).
7. Accelerate development of fuel cell energy storage systems through technology assessment and preliminary system design.
8. Ensure the efficient and safe application of distributed resources by compiling up-to-date information on interconnection hardware.
9. Conduct a Tailored Collaboration (TC) project entitled "Emissions Testing and Certification Guidelines for DG Generators."

Actual Outcomes:

1. Unbiased Information.
   - A quarterly newsletter—*Strategic Intelligence Update: Technology Development*—was published on the latest breaking information on DR technology and research development.
   - An online version of *EPRI Distributed Resources Technical Assessment Guide (DR-TAG)* was made available to CEC staff. The web-based Guide includes information on product configurations, technology status, development issues, and prospects for future improvements.
   - A technical report—*Enhancing DR Value Through Heat Recovery* (1003958)— was published on heat recovery options that could improve the performance and efficiency of DR technology.
   - The 2nd Annual Business Venture Forum, an annual national workshop, was held July 25-26 in San Francisco. It provided a forum for utilities, energy companies, equipment manufacturers, and vendors to discuss the latest technology, market, and policy developments.
   - Advisory Group Meetings were held in February, July, and October.
2. Evaluation Guide.
   - The *Guide for Test and Evaluation of DR Technology Performance* (1003963) was published, providing a uniform methodology and references for consistent evaluating and testing of emerging DR technologies.
3. Advanced Engines.
   - A report—*Insights on Development of Advanced IC Engines* (1003959)—was published to report on state-of-the-art engine technology under development at manufacturers, U.S national laboratories, and universities. The report assesses engine R&D activities for their potential to improve engine performance and/or reduce emissions.
   - A report—*Performance Data: Benchmarking of New and Emerging Engine Products* (1003960)—was published on performance characteristics of leading engine products from every major reciprocating engine manufacturer.
   - A report—*Case Studies of IC Engines for T&D Support* (1003961)—was published on utility application experiences and lessons learned with engines and combustion turbines used for T&D support.
4. Small Gas Turbines (1-10 MW) for Distributed Power Markets.
   - A report—*Case Studies of CTs for T&D Support* (1003962)—was published to document one utility's efforts to select, site, install, and operate a mobile combustion turbine at a rural substation.

5. Microturbines.
   - A report—*Performance and Electrical Characterization Tests on a Microturbine Commercial Prototype: Part III* (1003964)—was published to characterize operation of a grid parallel/grid independent commercial MTG.
   - A report—*MTG Field Test Program* (1006394)—was published to ascertain the cost, performance, durability, reliability, and maintainability of various microturbines in an actual customer environment.
   - A report—*Test and Evaluation of Two Microturbines at Customer Sites* (1006591)—was published to report the test results of two microturbines operating at customer sites. Also, to report the problems and other challenges encountered, along with customer viewpoints.
6. Fuel Cell Distributed Power Systems.
   - A report—*Assessment of SOFC-CT Hybrids* (1003965)—was published on the technical and performance characteristics of a 250-kW SOFC-microturbine system.
   - A report—*Assessment of SOFC Systems for C&I Applications* (1003966)— was published to provide validated bench-scale and field test data on small SOFC cogeneration systems.
   - A report—*5 kW Fuel Cell for Telecom and Residential Markets* (1003967)— is in process, and will be published March 31, 2002. The report will describe performance, cost, and durability information on emerging residential fuel cell systems.
   - A report—*50-kW PEM Prototype Fuel Cell System, Interim Report* (1003968)—is in process and will be published March 31, 2002. The report will describe the performance of PEM fuel cell systems for commercial and industrial applications.
7. Fuel Cell–Energy Storage Systems.
   - A report—*Technology Assessment of Fuel Cell–Energy Storage Systems* (1004544)—was published, detailing the performance of a PEMFC-Ultracapacitor system for stationary battery replacement markets.
8. Interconnection Hardware.
   - A report—*Technology Assessment of Interconnection Products for Distributed Resources* (1003969)—was published to provide an annual report on vendors, product development efforts, and R&D issues related to interconnection and switchgear technology.
   - A report—*Capacitor-Stabilized Soft Transfer Interface System for Distributed Resources* (1003970)—was published to report on development and testing of a prototype device that can improve the performance, reliability, and economics of DR systems.

Project Status:
The project has been completed.

Energy Source Stabilizer (ESS)

Contract #: 500-97-012 **Project #:** 14
Contractor: Edison Technology Solutions/Southern California Edison
Project Amount: $250,000
Contractor Project Manager: Moham Kondragunta (626) 815-0507
Commission Contract Manager: Linda Davis (916) 654-3848
Status: Completed

Project Description:
This project developed and demonstrated an Energy Source Stabilizer (ESS) that functions through a generating machine governor or other electronics-controlled power device to stabilize electrical frequency oscillations between various areas. Inter-area oscillations can cause very wide spread and costly power outages that may last for many days. Control of these dynamic oscillations through the generating machine governors is more effective and inexpensive than the existing power system stabilizers that function through the generating machine excitation system. Once proven, the ESS units can be installed on all generating machines having state-of-the-art rapid response governors.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing the incidence of large-scale power outages.
- Improving the energy cost and value of California's electricity by providing a low-cost means of improving system reliability.

Proposed Outcome:

1. Stabilize low frequency dynamic system oscillations by modulating the real power of generators, thereby improving system stability and reliability.

Actual Outcomes:

1. Two Energy Source Stabilizers (ESS) were installed at Alamitos Generating Station in Southern California and ESS performance was monitored during system disturbances to validate the working of ESS.
2. The ESS operated as expected to dampen oscillations that otherwise may have increased to cause a widespread power outage.
3. Multiple ESS units need to be installed throughout the Western Systems Coordinating Council (WSCC) system to achieve the reliability benefits possible with this technology. It is estimated that the increase in energy import capability due to the reliability improvements of installing ESS can save California electric customers approximately $15-20 million per year.

Project Status:
The project has been completed.

Enterprise Infrastructure Security - Target 86

Contract #: 500-00-023 **Project #:** 15
Contractor: Electric Power Research Institute (EPRI)
Project Amount: $45,000
Match Amount: $1,209,615
Contractor Project Manager: Jim Fortune (650) 855-2500
Commission Contract Manager: Laurie ten Hope (916) 654-4637
Status: Completed

Project Description:
The purpose of this project is to address concerns over the security of the energy industry's electronic infrastructure against cyber and physical threats. These threats range from corporate espionage by competitive rivals to sabotage by hackers or terrorists. Immediate concerns center on the vulnerabilities of electronic operations systems such as supervisory control and data acquisition (SCADA) and plant distributed control systems (DCS) and their interconnectivity with corporate business systems. As the energy industry becomes increasingly automated and electronically connected, a concerted cyber attack could be catastrophic from business, customer and national security perspectives. This project identifies and addresses security issues through a series of working group meetings that include staff and managers from the Energy Commission and other agencies, with the ultimate goal of developing more robust electronic security programs. Meetings and workshops provide forums for sharing information on best practices, lessons learned, and vulnerability assessment results.

This project supports the PIER Program goal of:

- Improving the reliability of California's electricity by leveraging the collective knowledge of the participants to develop strategies for protecting the state's critical electric power infrastructure against cyber and physical threats.

Proposed Outcomes:

1. Organize and facilitate workshops for collaborative exchange of information and ideas to support the development of robust security programs.
2. Provide guidelines, policies and procedures reflecting the collective knowledge of the industry for the following activities:
   - Specifying equipment procurement.
   - Performing tradeoffs between equipment performance and security.
   - Interfacing between information technology (IT) and operating systems.
3. Enhance the dedicated EIS website with expanded content to provide more and higher value information.
4. Engage key operating systems vendors and collaboratively develop security-based functional specifications for new hardware and software.
5. Develop a risk assessment framework to help decision makers understand and evaluate the costs and benefits of different security measures.

Actual Outcomes:

1. Workshops – Four topical workshops were delivered in 2001.
2. Guidelines, Policies and Procedures – The following technical reports were published in 2001 and are available on the members-only EIS web site:
   - Equipment Procurement Guidelines.
   - Performance/Security Tradeoff Guidelines.

- Interfacing IT and Operations Systems Guidelines.
- Generic Policies and Procedures.

3. Website.
   - The EIS member website was expanded.
4. Security-Based Specifications.
   - A technical report was published that describes generic specifications for operating system software and hardware resulting from the collaborative efforts of vendor action groups.
5. Risk Assessment Framework.
   - A web-accessible risk assessment framework was developed.

Project status:
The project has been completed.

Flexible AC Transmission Systems - Target 38A

Contract #: 500-00-023 **Project #:** 16
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Siemens Power Transmission & Distribution
Project Amount: $62,500
Match Amount: $274,237
Contractor Project Manager: Aty Edris (650) 855-2311
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
The purpose of this project is to demonstrate an advanced controller technology with the potential—if it were applied—to substantially increase power transfer capability on the transmission grid in California and the western region. The Convertible Static Compensator (CSC) is the latest FACTS (Flexible Alternating Current Transmission System) Controller developed under EPRI's FACTS technology development and application program. The CSC is an innovative power electronics-based controller that provides multiple compensating modes, which are needed to securely increase power transfer capability limits of existing transmission systems. The Controller provides flexible dynamic voltage control (to avoid voltage instability), as well as simultaneous real and reactive power flow control on multiple transmission corridors (without risk of transient or dynamic instability). The CSC offers this flexibility by allowing its converters to be connected in shunt, in series, in shunt/series, or in series/series with two lines.

This EPRI project supports demonstration of the world's first CSC—two 100-MVA Voltage Source Converters—which has been installed and is in operation at New York Power Authority's (NYPA) Marcy Substation in Utica, New York. The CSC is enabling NYPA to mine 240 more MW of power from the grid precisely when they need it most—during contingency situations. Membership in this project provides the Energy Commission with key technical information on installation and operation of the CSC, and integration of the CSC in a power grid.

This project supports the PIER Program objectives of:
- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system.
- Improving the safety/security of California's electricity system by developing technologies to maintain and enhance system security in the face of increasing traffic and congestion, while avoiding the environmental impacts associated with new transmission lines and corridors.

Proposed Outcomes:
1. Install CSC voltage source converters for shunt and series compensation.
2. Conduct initial field tests.

Actual Outcomes:
1. Phase 1 of the project (Static Synchronous Compensator [STATCOM] operation) was successfully commissioned in June this year.
2. CSC in the shunt operation modes (+/-200 Mvar STATCOM) is now in service, and is being monitored for fine-tuning the control and protection system.
3. A dedication ceremony was held June 21 to mark the startup of the first phase of the CSC.

4. A technical progress report Convertible Static Compensator (CSC) for New York Power Authority, EPRI no. 1001970, was published.
5. A review of the CSC operation was presented at the FACTS Users Group Meeting on October 18-19, 2001 in New York City.
6. An EPRI "Innovators" document, quantifying the benefits of the CSC, is currently under development and will be published by the end of December 2001 or early January 2002.
7. Work is under way on the series operation modes—Static Synchronous Compensator, Unified Power Flow Controller, and Interline Power Flow Controller.
8. Installation of two bypass switches is under way.

Project Status:
The project has been completed.

Grid Operations and Management - Target 39

Contract #: 500-00-023 **Project #:** 17
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: ABB Power T&D Co., Inc. : Best Systems, Inc. : Bonneville Power Administration : Decision Systems International : Hoffman Publications, Inc. : Incremental Systems : Iowa State University : Quality Training Systems : Xtensible Solutions, Inc.
Project Amount: $201,923
Match Amount: $5,156,709
Contractor Project Manager: Stephen Lee (650) 855-2486
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
The purpose of this project is to support EPRI's collaborative program in Grid Operations and Management, which is developing new tools and information that could be used to more efficiently and reliably operate the electricity power grid in California and the western region. EPRI products enable power system operators to cost-effectively upgrade systems, merge databases from different sources, exchange information in real time, and better manage systems during and following emergencies. To ensure the grid is capable of supporting the competitive market, EPRI software also offers capabilities for more accurately estimating and monitoring power system transactions. In addition, as the number and scale of transactions on the California grid increase, and as system security is challenged, EPRI provides new information and approaches for ensuring the reliability of the system.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system.
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Provide software and information to reduce the costs and improve the efficiency of control center operation.
2. Provide software, methods, and information to enhance the transaction without impact on security.
3. Provide new methods and information to improve the security of the system and avoid management capabilities of transmission system operations, and to allow increased transactions system failures.

Actual Outcomes:

1. Reduce the Costs and Improve the Efficiency of Control Center Operations.
    - Three sets of tests were conducted that demonstrated a common language for information sharing among utility applications. In the tests software vendors exchanged versions of the Common Information Model (CIM) translated into the industry standard eXtensible Markup Language (XML), which permits the exchange

of power system models in a format that any Energy Management System can understand using Internet or Microsoft technology.

- A proposal was developed for a CIM standard, which would permit assembling diverse sources of enterprise data into a common database.
- Two reports were produced on changes necessary to the existing standard for the real-time standard for data exchange.
- Version 2.0 of EPRI's GOP Graphics System was developed and tested. The software, which provides a standard Graphical User Interface (GUI) for any EPRI gird operations software, was upgraded to allow remote access to applications.
- Two products were developed to educate operators in emergency system management and restoration: the Tutorial for System Restoration and Version 2.0 of the Operator Training Simulator (OTS).
- *Instructor Guidelines for Use of an Operator Training Simulator* was published.
- A tri-annual newsletter was published on new software programs and methods for improved transmission grid operation.

2. Enhance Transaction Management.
   - Two reports were published on design specifications for a Topology Estimator and a beta version of Topology Estimator software was developed. This product will enable accurate estimate of the real-time network topology status, which is crucial for correct scheduling of generations and transactions.
   - EPRI participated in industry collaborative efforts to develop electronic scheduling capabilities, including Version 1.4 of the transaction management software Open Access Same-time Information System (OASIS) software.
3. Improve System Security.
   - A report was published that summarizes the 15 major accomplishments of EPRI's Security Mapping and Reliability Index Evaluation (SMRIE) project, which provides system operators with the capacity to monitor security levels quickly and accurately.
   - A report was published that describes on-line capabilities for detecting high-risk, or N-k, contingencies that result in unscheduled outages of multiple components within bulk high-voltage electric transmission systems.
   - A report was published that provides a systematic procedure for determining the effects on an entire power network of hidden failures in protection systems.

Project Status:
The project has been completed.

Grid Planning and Development - Target 40

Contract #: 500-00-023 **Project #:** 18
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Best Systems, Inc. : Decision Systems International : Electricite de France : EPRIsolutions : P Plus Corporation : Southern Company Services, Inc. : Vanessa MacLaren-Wray, dba
Project Amount: $98,077
Match Amount: $4,282,593
Contractor Project Manager: Stephen Lee (650) 855-2486
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
The purpose of this project is to increase the speed and efficiency of planning tools. Grid planning cycles today in California and throughout North America are continually being compressed. To make effective decisions under these conditions, power system planners need tools that allow them to rapidly obtain and process information, solve complex problems, and, in some cases, provide a sound business justification for their decisions. In addition, planners must often seek to maximize the value of their power grid assets while at the same time maintaining system reliability.

EPRI products in this area are designed to meet new grid planning needs in California and elsewhere by increasing the speed and efficiency of planning tools. For example, one product will help planners take advantage of advances in grid operations tools by improving capabilities for sharing real-time data with grid operations applications. Other products are increasing capabilities of existing software for simulation and analysis of grid conditions. EPRI is also strengthening capabilities for evaluation of grid security and providing new tools for conducting cost/benefit studies. The one-day workshop sponsored by this target in association with the Energy Commission provided a large public forum for evaluation of alternative wholesale market structures for California.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system.
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Develop and upgrade grid planning software and methods to increase the speed and efficiency of their analytical capabilities and improve their ease of use.
2. Enhance grid planning software used for assessing transmission system reliability.
3. Improve grid planning software with capabilities for cost/benefit analyses of network additions and constraints.
4. Conduct a co-funded project entitled "Workshop on Exploring Alternative Wholesale Market Structures for California."

Actual Outcomes:

1. Improve Software Efficiency and Ease of Use.
   - Two mainline planning applications—IPFLOW and DYNAMICS—were integrated with a database compliant with the Common Information Model (CIM), enabling these planning applications to utilize real-time operating data and share data with operators.
   - New computational techniques to increase analysis speed were developed for a restructured version of the Electromagnetic Transients Program (EMTP), a software widely used for simulating and identifying solutions for high-speed transients. *Restructured Electromagnetic Transients Program Progress Report: (EMTP-RV) (1001989).*
   - Object-oriented technology was applied to the Power Systems Analysis Package (PSAPAC) software, which will increase the processing efficiency and substantially reduce the cost of development.
   - Version 6.0, incorporating an improved graphical user interface, was developed for the Interactive Power Flow (IPFLOW) program, which supports a family of planning applications, including ETMSP, VSTAB, and SSSP.
   - Version 2.0 of EPRI's GOP Graphics System was developed, providing a standard graphical user interface for all EPRI grid planning applications.
   - Software support was provided to users of EPRI's grid planning and development software, including ongoing distribution and maintenance, user group support, and software enhancements.
   - A triannual newsletter was published on new software programs and methods for improved transmission grid planning.
2. Strengthen Capabilities for Reliability Assessment.
   - A report –*Restructured Transmission Reliability Evaluation for Large-Scale Systems (TM) (TRELSS (TM)): An Implementation Plan (1001987)* - was published on progress in upgrading EPRI's Transmission Reliability Evaluation for Large-Scale Systems (TRELSS)—commonly used for assessing reliability of bulk power systems—to update its computational techniques, GUI, database management, and use of object-oriented technology.
   - A report - *Modeling and Diagnosis Methods for Large-Scale Complex Networks: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report (1006092)* – was published that presents progress on modeling and diagnosis methods for large-scale complex networks.
   - A report - *Intelligent Management of the Power Grid: An Anticipatory, Multi-Agent, High Performance Computing Approach: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report (1006091)* – was published that describes the progress made in understanding the grid as a customer-driven, anticipatory system.
   - A report - *Minimizing Failures While Maintaining Efficiency of Complex Interactive Networks and Systems: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report (1006093)* - was published that discusses minimizing failures while maintaining efficiency of complex interactive networks and systems.
   - A report - *Context-Dependent Network Agents: EPRI/DoD Complex Interactive Networks/Systems Initiative: Second Annual Report (1006094)* - was published that presents progress on developing and demonstrating "context-dependent network agent" (CDNA) technology.
   - A report - *From Power Laws to Power Grids: A Mathematical and Computational Foundation for Complex Interactive Networks: EPRI/DoD Complex Interactive*

Networks/Systems Initiative: Second Annual Report (1006095) – was published that focuses on understanding the behavior of large-scale complex interactive networks and investigating their mathematical underpinnings.

3. Enhance Capabilities for Cost/Benefit Analyses.
   - Version 5.0B of EPRI's DYNATRAN software (1001988)—which models economic costs and benefits of network constraints and additions—was developed, providing new computational capabilities.
4. Conduct Workshop on Alternative Marketing Structures.
   - EPRI facilitated a 1-day workshop on November 7, 2001, to explore alternative power market structures for California. The workshop created a large public forum that featured two presentations on new research, three panel discussions with experts from throughout the state, and an audience of about 100 attendees representing a broad cross-section of industry interests.

Project Status:
The project has been completed.

Interconnection Requirements for Distributed Energy Resources

Contract #: 700-99-010
Contractor: Onsite Sycom Energy Corporation
Contract Amount: $395,085
Contractor Project Manager: Crisman Cooley (805) 683-0938
Commission Contract Manager: Jon Edwards (916) 654-4851
Status: Completed

Project Description:
The purpose of the FOCUS-I project was to identify the barriers to Distributed Generation (DG) and make recommendations for removing those barriers, in the areas of interconnection, environmental review, and permit streamlining. This effort is critical for making DG, especially units smaller than 1 megawatt in size, a viable source of power for California in the future.

FOCUS-I is divided into the areas of:

1. Interconnection.
2. California Environmental Quality Act (CEQA) Review, Building Permitting and Air Permitting.

The interconnection portion of the FOCUS-I effort achieved 100% consensus on technical issues and 98% consensus on non-technical issues. The workgroup drafted Revised Rule 21 in interim and final versions. The California Public Utilities Commission adopted both late in 2000. Interconnection projects now use Revised Rule 21 for all DG interconnections in Investor-Owned Utility areas in California. Revised Rule 21 is estimated to have achieved approximately 50 percent efficacy in cost reduction, an average reduction in costs of approximately 37 percent for interconnection across all project sizes. The CEQA Review and permit streamlining tasks successfully identified all of the major permitting barriers and provided recommendations for their removal. One of the most important findings of the CEQA Review/Streamlining task is that training for regulators is essential to streamlining the DG siting process.

The project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity system.
- Improving the availability of energy and capacity, as well as reducing its (wholesale) cost.
- Improving the safety of California's electricity by allowing DG to interconnect safely.
- Improving the positive impact on California's economy by providing greater power availability with more options for electricity users at lower DG installation costs.

Proposed Outcomes:

- Identify the barriers to Distributed Generation (DG).
- Make recommendations for removing those barriers, in the areas of interconnection, environmental review, and permit streamlining.

Actual Outcomes:

1. The outcomes resulting from the Interconnection portion of the FOCUS-I project included:
    - Facilitating consensus on the technical issues of interconnection.
    - Making interconnection a single uniform process which is internally consistent and predictable statewide.

- Providing a method of Simplified Interconnection.
- Exploring the role of advanced communications and metering for interconnection scheduling and dispatch.
- Replacing the current prescriptive Interconnection Requirements (IRs) with Performance-Based Interconnection Requirements (PBIRs).
- Lowering the cost of interconnection.
- Fulfilling the need for interim standards.
- Addressing safety issues.
- Defining the scope and feasibility of type testing.
- Accelerating DG adoption by training and informing government agencies.
- Defining the scope of technologies covered by the Rule 21.
- Making changes to utility tariffs proceeding from interconnection rules.
- Facilitating interconnection of small units.
- Eliminating utility discretion of study fees.

2. The outcomes resulting from the CEQA Review and Permit Streamlining portion of the FOCUS-I project included:
   - Identifying barriers and proposing solutions to streamline the CEQA Review and Land-Use Approval process.
   - Identifying barriers to DG in the building permitting process and producing recommendations for removing or mitigating those barriers.
   - Identifying barriers to DG in the air permitting process and producing recommendations for removing or mitigating those barriers.

Project Status:
This contract was completed on June 30, 2001. Recommendations were made in the final report for follow-on work to conduct case studies and further refinement of Rule 21. The case studies are needed to characterize the electrical effects of DG units on the distribution system. This follow-on work is being conducted in FOCUS II, contract #500-00-013.

Light-Activated Surge Protection Thyristor for Distribution System Reliability

Contract #: 500-98-038
Contractor: OptiSwitch Technology, Inc.
Subcontractors: SRI International : Telecom Data. : Silicon Power Corporation
Contract Amount: $494,239
Match Amount: $93,292
Contractor Project Manager: David Giorgi (858) 452-8787
Commission Contract Manager: Jon Edwards (916) 654-4851
Status: Completed

Project Description:
The purpose of this project was to determine whether it is technically and economically feasible to replace electronically activated surge protection thyristors currently installed on high-power transmission and distribution systems with the improved custom light activated surge protection thyristors. Specifically, this Contractor designed, fabricated, and laboratory tested the LASPT to determine if it has superior technical performance characteristics to that of a conventional thyristor.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity system by lowering the state's vulnerability to catastrophic outages by preventing cascading power failures due to rapid surges. This project also supports the PIER Program's strategic energy research objective under the revolutionary science attribute of designing and manufacturing a unique optical coupling to complete the development of the custom LASPT.

Proposed Outcomes:

1. Design, fabrication, and laboratory testing of a light activated surge protection thyristor.
2. Exhibit a surge response rate of 10 k (kilo) amps per microsecond (10 kA/µs).
3. Exhibit a peak current rate of 15 k (kilo) amps (15kA).
4. Exhibit minimum blocking voltage capability of 2700 volts (V).

Actual Outcomes:

1. The project exceeded the contract performance requirements at three testing levels:
   - The first requirement exceeded the "Blocking Voltage parameter by 63%. The contract requirement was 2,700 volts, and the measured result was 4,400 volts.
   - The second requirement exceeded the Peak Current parameter by 213%. The contract requirement was 15,000 amperes, and the measured was 47,000 amperes.
   - The third requirement exceeded the Rate of Rise of Current parameter by 420%. The contract requirement was 10,000 amperes/microsecond, whereas the measured was 52,000 amperes/microsecond.
2. The final objective was to determine the production unit price for the LASPT device. The cost was $1,200 per device for several hundred units and $700 for high volume production.

Project Status:
This PIER contract is complete. LASPT is seeking commercial partners.

Phasor Measurement Units

Contract #: 500-97-012 **Project #:** 12
Contractor: Edison Technology Solutions/Southern California Edison
Project Amount: $150,000
Contractor Project Manager: Moham Kondragunta (626) 815-0507
Commission Contract Manager: Linda Davis (916) 654-3848
Status: Completed

Project Description:
This project demonstrated real-time monitoring and potential of future control of the Western Systems Coordinating Council (WSCC) electric power grid using Phasor Measurement Units (PMUs), which are low-cost sensors that measure voltage, current phase angles and magnitudes that are time tagged for relative comparison between geographically distant locations in Southern California and Oregon.

The PMUs communicate real-time data to a Phasor Data Concentrator (PDC) at very high speed using communication systems from all the monitoring sites. The system will allow various energy control centers and systems to monitor the entire WSCC system and will help to provide information to prevent wide scale power outages. The project will develop a system to pool data from all major WSCC members and make it available to all participating members for post-disturbance analysis.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by allowing regional energy control centers and systems to monitor the entire WSCC system.
- Improving the energy cost/value of California's electricity by reducing wide scale power outages.

Proposed Outcomes:

1. Develop a system that facilitates real-time monitoring of regional transmission facilities.
2. Develop low-cost sensors and software for use with a high-speed communication system that allows utilities and eventually regulators to monitor the status of regional transmission and distribution lines.

Actual Outcome:

1. Two PMUs installed in Southern California Edison (SCE) with communication systems resulted in data collected at a very high speed from all the monitoring sites for viewing grid disturbance data of the Bonneville Power Administration in Oregon and at SCE in Southern California.

Project Status:
The project has been completed.

Power Quality Impacts of Airport GSE Charging Systems

Contract #: 100-98-001 **Project #:** 33
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Georgia Tech/National Electric Energy Testing Research & Applications Center (NEETRAC)
Project Amount: $91,500
Contractor Project Manager: Andra Michel (650) 855-2101
Commission Contract Manager: McKinley Addy (916) 657-0833
Status: Completed

Project Description:
This project will study the existing GSE charging systems at five airports (including four in California) to document the power quality characteristics of the systems and assess their impacts on the primary and secondary electric distribution systems that supply power to the airports and gate areas.

This project supports the PIER Program objective of:
- Improving energy cost/value.

Proposed Outcomes:
1. EPRI hosted monthly conference call meetings that brought together airport and utility participants, as well as representatives from the Energy Commission, EPRI, and the subcontractor, NEETRAC, for project status reporting and planning for future tasks. Minutes of each meeting were compiled and distributed to participants.
2. Task 1 (Data Collection) was completed. Data recorders were installed and data collected at three airports—San Francisco, Sacramento, and Orange County. Arrangements for data collection at airports in Los Angeles and Dallas/Fort Worth are ongoing. A report – Power Quality Characteristics of GSE Charging Systems – is in draft.
3. Task 2 (Model Development and Validation) is scheduled to be completed February 28, 2002. Task 3 (Case Studies A) is scheduled to be completed May 31, 2002. Tasks 4 (Case Studies B) and 5 (Technology Transfer) have not yet been funded by the Commission.

Actual Outcomes:
1. This study documented the characteristics of electric GSE charging systems at five airports (including four in California) and assessed their impacts on the secondary and primary electric distribution systems that supply power to the airports and their gate areas. The findings will help airport authorities to determine the least-costly, most energy efficient, and most reliable methods to supply electric power to airport gate areas. The findings are summarized in an EPRI technical report—*Power Quality Impacts of Airport Ground Support Equipment Charging Systems* (1007294).

Project Status:
The project has been completed.

ESI Projects Completed in 2000

Airport Solutions

Contract #: 100-98-001 **Project #:** 2
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Hawaiian Electric Company, Inc. : Carey Transportation : Henry C. Larry
Project Amount: $128,000
Match Amount: $428,610
Contractor Project Manager: Layla Sandell (650) 850-2756
Commission Contract Manager: McKinley Addy (916) 657-0833
Status: Completed

Project Description:
The purpose of this project is to develop new environmental and energy technologies and apply existing technologies, such as electric vehicles, to airport infrastructure to reduce pollution and subsequent costs. In addition, the project will develop improvements to airport efficiency, productivity and safety. Commercial airports are microcosms of all sectors of the electricity marketplace, are major energy users, and are of vital importance to the economic health of their surrounding community. The contribution to local and regional economies from California's largest airports is hundreds of millions dollars every year. However, airports face new and ongoing challenges. Citizens in surrounding communities question the impacts of airports on their quality of life. Reducing overall pollutant emissions from airport facilities has become a high priority issue. These issues could limit airport growth and in turn impact local and regional economies.

Converting ground transportation and other airport equipment to electricity is one solution to these issues. Inside terminals, the installation of electrically powered equipment can improve indoor air quality, reduce HVAC system operating costs, and prevent disruptions in power quality-sensitive equipment. Outside terminals, the use of electrified equipment and vehicles can provide annual operating cost savings exceeding $500,000. In addition, emission reductions of up to 80 percent could be expected at airports that convert much of their ground transportation and equipment to electricity. EPRI's Airport Solutions Target has developed the necessary methodologies and models to assess the feasibility of electrification and the associated economic and environmental benefits on an airport-specific basis. Through the development and deployment of electrotechnologies, sustainable growth of airports will be enhanced, and energy savings will be attained.

This project supports the PIER Program objectives of:
- Improving the energy cost/value of California's electricity by providing information on efficiency improvements available for use by airports.
- Improving the environmental and public health costs/risks of California's electricity by reducing emissions from the internal combustion engines used by airport facilities by encouraging replacement with electrically-powered equipment.

Proposed Outcome:
1. Provide information on energy solutions to support the improvement and growth of California airports.

Actual Outcomes:
1. Information on energy solutions for airports.
    - EPRI organized a pioneering project to electrify American Airlines airport ground support equipment (GSE) at Detroit Metro Airport. This first-of-its-kind project

electrified 132 pieces of GSE by the end of 2000, and is scheduled to electrify the airline's entire fleet of 1070 vehicles over the next five years. Case study results were published.

- EPRI hosted an Electric Ground Support Equipment Market Penetration Issues Round Table in June 2000 in Sacramento, CA. The meeting brought together more than 40 representatives of California airports, airlines, vehicle and component manufacturers, a standards-making body, and utilities to address key issues. A proceedings of the meeting was published. A second round table was held in October 2000 at LaGuardia Airport.
- The latest information was received from the FAA's Inherently Low-Emission Vehicle (ILEV) pilot program, which seeks to achieve environmental benefits through the use of low-emission vehicles.
- A life-cycle cost-evaluation model and spreadsheet were developed to compare life-cycle costs of electric versus internal combustion-based GSE fleets under different scenarios of operation, thereby assessing the economic benefits of the cleaner airport vehicles.
- EPRI participated in the planning of a GSE Data Collection Project with Southern California Edison to meter equipment and collect performance, battery management, and metering data.
- EPRI participated in the planning of a 12-month Power Quality Impact Study involving the characterization of electric GSE charging systems.
- Information was provided on the environmental benefits of ozonation of cooling towers at an airport in Shreveport, Louisiana.
- EPRI participated in the National Electric Vehicle Association Infrastructure Working Council (IWC) GSE connector standardization meetings to develop functional specifications for electric GSE connectors, thereby providing a supporting infrastructure for electric GSE, and ensuring safety and reliability of fast charging.

Project Status:
The Commission's participation in this target ended December 31, 2000.

Development of a Composite Reinforced Aluminum Conductor

Contract #: 500-98-035
Contractor: W. Brandt Goldsworthy & Associates, Inc.
Contract Amount: $75,000
Match Amount: $65,000
Contractor Project Manager: Clem Hiel (626) 351-2082
Commission Contract Manager: Linda Davis (916) 654-3848
Status: Completed

Project Description:
The purpose of this project is to improve the reliability and capability of California's transmission and distribution system by developing a stronger and lighter conductor to replace these aging and overloaded power lines. Specifically, this project will develop a composite reinforced aluminum conductor (CRAC) to replace conventional conductors made from aluminum wires wrapped over a core of steel strands (called aluminum conductor - steel reinforced (ACSR) conductors). Many miles of California's overhead electricity transmission lines have reached the end of their service lives or are being stressed beyond their design limits due to load growth and heavy power transfers across longer distances. This technical development is very timely as the current age of transmission lines ranges from 30 – 70 years.

W. Brandt Goldsworthy and Associates, Inc. of Torrance, CA, with additional match-funding support from the DOE and private industry, is reconfiguring aluminum conductors around a lightweight composite strength member whose weight is approximately 25 percent of the traditional steel strength member. The resulting lightweight conductor can be optimized for reduced sag and increased ampacity. CRAC conductors can withstand adverse weather and high load conditions, thereby avoiding power outages caused by line sagging and swinging, high winds and ice buildup.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by avoiding power outages caused by line sagging and swinging, high winds and ice buildup.
- Improving the energy cost/value of California's electricity by reducing losses and the costs of replacing conductors.
- Improving the environmental and public health costs/risks of California's electricity by reducing the need for new transmission lines.
- Improving the safety of California's electricity by significantly reducing the potential for line clearance violations.

Proposed Outcomes:

1. Design, fabricate and test a robust, practical and cost-effective composite reinforced aluminum conductor.
2. Target market price for CRAC is $1.00 per product pound, which is approximately the cost of aluminum conductors which are steel reinforced.
3. Five percent more electrical conductivity, compared to steel reinforced aluminum conductor.
4. Reduced mechanical elongation (line sag) at high operating temperatures.
5. 250 percent stronger than steel reinforced aluminum conductor.
6. 75 percent lighter than steel reinforced aluminum conductor.

Actual Outcomes:

1. Two CRAC, CRAC-121 (one-to-one) and CRAC-Advanced, were developed during this project. Both achieved:
   - Five percent more electrical conductivity than DRAKE.
   - A minimum of 40 percent more ampacity than DRAKE.
   - Twenty percent less mechanical elongation at ambient operating temperatures.
   - A 30 percent strength increase compared to DRAKE.
   - Only a 25 percent weight reduction was achieved and the objective of a 66 percent reduction was not met. In retrospect, this turned out to be an ill-posed objective because the maximum possible weight reduction, achieved by taking all the steel out of the DRAKE conductor, is only 33 percent.
2. Splicing techniques were developed and demonstrated for both CRAC.
3. A splicing tool was developed to splice the composite strength member.
4. There were two very positive unanticipated outcomes.
   - CRAC conductors were found to operate 9 (CRAC-121) to 25 percent (CRAC Advanced) cooler than ACSR conductors.
     - Both conductor designs can carry optical fibers in the hollow center. When optical fibers are added, these conductors are called CRAC-TelePower.

Project Status:
The project has been completed.

Distributed Generation (#733)

Contract #: 100-98-003 **Project #:** 2
Contractor: Gas Research Institute
Subcontractors: KN Services : Onsite Sycom Energy Corporation : AEC
Project Amount: $41,000
Contractor Project Manager: Ron Edelstein (847) 768-0889
Commission Contract Manager: Scott Tomashefsky (916) 654-4896
Status: Completed

Project Description:
The purpose of this project is to identify the application characteristics and technical requirements for the strategic utilization of gas-fired distributed generation beyond the electric distribution substation. The tasks undertaken in this program include 1) preparing an economic assessment of the market potential for installing distributed generation units, 2) developing modeling tools to identify options available to customers, and 3) developing integrated interconnection systems.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by utilizing natural gas-fired distributed generation technologies.
- Improving the public health costs/risks of California's electricity by advancing the use of low-emission natural gas.

Proposed Outcomes:
During 2000, the following tasks will be completed:

1. Provide benefits, impacts, and issues information from four field test applications.
2. Provide two advanced controls and communications systems for distributed generation.
3. Provide reports on infrastructure and interconnection system requirements, as well as communication protocol needs.

Actual Outcomes:

1. Provide benefits, impacts, and issues information from four field test applications:
   - Beta version of D-Gen Pro (Version 3) made available for user testing.
2. Provide two advanced controls and communications systems for distributed generation:
   - Installed a 1.2 MW gas turbine genset with novel communication/control equipment has been installed at Texas Tech.
   - A retrofit of the existing reciprocating engine facility at Lovelace Medical Center, a 235-bed, full service hospital, located in Albuquerque, New Mexico was recently completed. A new communication/control system was installed to enable the hospital to benefit from instantaneous interruptible electric power rates.
3. Provide reports on infrastructure and interconnection system requirements and communications protocol needs.

Project Status:
The project has been completed.

Distributed Resources Demonstration

Contract #: 500-97-011 **Project #:** 4
Contractor: San Diego Gas and Electric Company
Project Amount: $450,000
Contractor Project Manager: Al Figueroa (619) 654-8614
Commission Contract Manager: Jamie Patterson (916) 657-4819
Status: Completed

Project Description:
The purpose of this project was to demonstrate technology that would reduce the cost of parallel interconnection to electric distribution grids from distributed generation systems while still maintaining mandated safety and system protection features.

Technologies under consideration included solid-state interconnection devices and advanced generation systems such as new dual-fuel (90 percent natural gas, 10 percent diesel) reciprocating engines, advanced gas turbines, and microturbines.

Objectives:

- Demonstrate a solid-state interconnection device with remote dispatching and control capabilities.
- Demonstrate an advanced dual-fuel generator (90 percent natural gas and 10 percent diesel).
- Demonstrate other advanced generation systems.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by improving the integrity, reliability and safety of California's energy supply system through diverse distributed electrical resources. In addition, this project addresses electrical distribution issues raised by deregulation of the California electricity industry.

Proposed Outcomes:

1. Solid-state interconnection device connected to an electric utility distribution grid was successfully implemented and demonstrated.
2. Dual-fuel systems can not obtain permits because of emission constraints.
3. Other advance generation technology was not available in time to meet project schedule.

Actual Outcomes:

1. Solid-state interconnection device can safely interconnect in parallel to electric grid.
2. Solid-state interconnection device is relatively the same size and has the same ease of operation with a wide range of generator sizes.
3. Solid-state technology shows promise for reducing cost of interconnection.
4. The dual-fuel generator originally proposed would not be cost effective as a distribution-generation option because of emission control costs in California.
5. Other advanced generation technologies (such as microturbines and advanced gas turbines) showed promised but were not ready in time to meet the schedule for this demonstration.

Recommendations

1. Demonstrate the solid-state interconnection device with automatic transfer switch and test under live power outage condition.
2. Look at alternative suppliers of solid-state interconnection devices to provide competition to reduce cost and improve quality of product and services.
3. Demonstrate the incorporation of advance generation systems with the solid-state device when such systems become available.

Project Status:

The project has been completed. The final report is posted on the PIER website and is titled Demonstration and Evaluation of Solid-State Interconnection System (Publication # 600-00-035).

Dynamic Circuit Thermal Line Rating (DCTR)

Contract #: 500-97-011 **Project #:** 5
Contractor: San Diego Gas and Electric Company
Project Amount: $110,000
Contractor Project Manager: William Torre (858) 654-8349
Commission Contract Manager: Linda Davis (916) 654-3848
Status: Completed

Project Description:
The purpose of this project was to develop and demonstrate real-time transmission line ratings. DCTR uses equipment mounted on a transmission tower to monitor the line conductor tension and determine ground clearances and weather conditions to calculate the amount of current that can be transmitted in real time. This information is provided to system operators or engineers for their use in safe, reliable and economic system operation. Conventional transmission lines ratings have been established as static rating, which may be lower than the maximum capability of the conductor. By monitoring wind speed, conductor tension and solar heating, a real time line rating may be calculated that is closer to the maximum conductor capability.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity since using real time dynamic line ratings ensures reliability and quality by making sure that ground clearances are not exceeded thus avoiding contact and flashovers which cause power outages and voltage surges.
- Improving the energy cost/value of California's electricity by improving transmission line utilization to facilitate economic transactions and reduce costs as real time ratings allow greater power transfers on existing facilities than the static line rating.
- Improving the environmental and public health costs/risks of California's electricity by improving utilization of existing transmission lines thereby avoiding the need for new lines and the associated environmental impacts.
- Improving the safety of California's electricity by using real time information to make certain that ground clearance limits are not exceeded thus avoiding the risk of electrical shock and fires.

Proposed Outcomes:

1. Increase transmission capacity on congested transmission lines to allow increased power transfers.
2. Reduce use of expensive generators which "must run" due to transmission rating constraints.
3. Promote the use of more economic generators to result in reduced energy system price for utility customers.

Actual Outcomes:

1. The dynamic real time rating for the demonstration was up to 150 percent more than the normal rating at some times. From 9 a.m. through 5 p.m., the dynamic rating averaged a 75 percent increase in rating over the normal rating on that circuit.
2. The real time rating also indicates that line ratings are sometimes reduced, and eliminates the risk of sagging the conductor to the point of contact thus preventing danger to the public.

Project Status:
The project has been completed.

Electric System Seismic Safety and Reliability

Contract #: 500-97-010 **Project #:** 9
Contractor: Pacific Gas and Electric Company
Subcontractors: University of California, Berkeley : Pacific Earthquake Engineering Research Center
Project Amount: $1,000,000
Contractor Project Manager: William Savage (415) 973-3116
Commission Contract Manager: Bob Anderson (916) 654-4206
Status: Completed

Project Description:
The purpose of this project is to support several major research projects in the field of electric system seismic safety and reliability. Projects ranged from the shake table testing of electric bushings and the collection of soil data at existing substations, to the development of a rapid response, strong ground shaking contour map program and related strong ground motion attenuation curves. Some of the early products have already been incorporated by a major California utility in their risk management practices. This contract was extended through January 31, 2000, due to the interruption of research report preparation by investigators assigned to assess damage in Turkey after the August 17, 1999, magnitude 7.4 Kocaeli earthquake.

This project supports the PIER Program objective of:

- Improving the reliability/quality of California's electricity by reducing the vulnerability of the electric transmission and distribution system due to damage caused by a major earthquake, continuation of power in an area affected by an earthquake and/or by the rapid recovery of the electric service. This rapid recovery will allow for a shortened interruption to emergency services and businesses due to the loss of electric power.

Proposed Outcomes:

1. Improvements to installed utility equipment will be identified and tested, and the potential for future disruptions due to earthquake-induced damage can be reduced.
2. Develop improved assessments of shaking-caused permanent ground deformation hazards in formats that the utility can directly use for evaluating electric system vulnerabilities.
3. Examine the process of fire initiation during power restoration following earthquakes to evaluate various means to reduce the risk of starting fires.
4. Develop the capability to analyze data from distant seismographic instruments to accurately predict the pattern and severity of strong earthquake shaking anywhere in the state.

Actual Outcomes:
Seven utility seismic topic areas were researched and the results are available in PIER Publication number 600-00-031F.

Project status:
The project has been completed.

Grid Operations and Management

Contract #: 100-98-001 **Project #:** 12
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: EPRI Conference Blan : ABB Systems Control : Bailey Network Management : Bonneville Power Administration : Cegelec ESCA Corporation : Decision Systems International : Duquesne Light Company : General Physics Corporation : General Reliability : Houston Lighting & Power Company : Incremental Systems, Inc. : Iowa State University : Kansas City Power & Light Company : KEMA Consulting, KEMA-ECC, Inc. : Oracle Corporation : Pattern Recognition Technologies : Potomac Electric Power Company : Quality Training Systems : Siemens Energy and Automation, Inc. : Siemens/Empros : TU Electric Company : University of Liege : Utility Consulting International : V&R Company : Energy Systems Research : Warsaw University of Technology : Washington State University
Project Amount: $370,000
Match Amount: $9,691,100
Contractor Project Manager: Dan Sobajic (650) 855-8537
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
The purpose of this project is to support EPRI's collaborative program in Grid Operations and Management, which is developing new tools and information to ensure that the power grid will be a gateway to efficient competition and the key to customer satisfaction. EPRI provides tools and information that offer guidance on how to respond to demands to safely push more power through the system without jeopardizing system security. EPRI's products give system operators a clear view of real-time grid conditions, and allow them to make decisions that take into account maximum use of the grid as well as reliability of the system. Examples include vital resources to support operator training, real-time software for Energy Management System (EMS) control and operation, and seamless communication between Energy Management Systems and power plants.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity through innovative technologies, which help to balance the competing needs of maximizing the use of the grid while maintaining the security of the system.
- Improving the energy cost/value of California's electricity by merging new tools for grid functionality with information for operating in the new competitive marketplace. EPRI technology development programs will help to increase transmission capacity across constrained interfaces, thus reducing grid-operating costs, while enhancing system security.

Proposed Outcomes:

1. Provide software, methods, and information to enhance the transaction management capabilities of transmission system operations, and to allow increased transactions without impact on security.
2. Provide software, methods, and information to maximize energy transfers and increase energy flows across constrained interfaces.
3. Provide software, methods, and information to increase the transmission system capacity.
4. Conduct a Tailored Collaboration entitled "EPRI Early Warning System Project" to identify and report Y2K anomalies and events in electric and natural gas operations from 12/31/99 through 1/4/00.

Actual Outcomes:

1. Transaction management.
   - Version 1.4 of the transaction management software Open Access Same-time Information System (OASIS) software was developed. A response was prepared to FERC Order 638 to enhance the functionality and performance of OASIS business practices.
   - A variety of open-system, standardized tools were provided that will permit the CA-ISO to implement advanced security applications without regard for existing proprietary databases. Tools include Version 1.0 of the Application Program Interface (API), which enables users to integrate applications from various sources, and a Topology Processor, which allows applications developed for planning environments to be integrated into operating environments.
   - Two reports were published on the Common Information Model (CIM), which provides a common language for information.
   - New graphical user interfaces were developed for existing grid operations applications to ensure they have a consistent look-and-feel.
   - EPRI's Operator Training Simulator was integrated with API and CIM to allow operators to be trained with CIM data.
   - Five restoration lessons were produced for the Emergency System Management and Restoration (ESMR) product.
   - A tri-annual newsletter was published on new software programs and methods for improved transmission grid operation.
   - A report was published summarizing gird operations and planning issues, needs, technological advances, and regulatory changes in the 2000-2005 time frame.
2. Increase power flows.
   - Version 2.0 was released of EPRI's Transfer Capability Evaluation (TRACE) software, which allows system operators to determine the maximum number of simultaneous power transfers possible.
   - TRACE was integrated with IEEE PSADD Common format to support the latest version of Power Technologies' PSS/E data formats.
   - A TRACE training workshop was held.
3. Increase transmission capacity.
   - EPRI's Dynamic Security Assessment (DSA) software was made available. DSA allows operators to increase loading on constrained networks by calculating stability limits on-line in real time.
   - Two reports were published on DSA and Risk-Based Security Assessment.
   - Version 1.1 was released of EPRI's On-line Voltage Security Assessment (VSA) software, which allows system operators to increase power transfers across voltage-constrained networks by calculating voltage limits on-line in real-time.
4. A web site was established and operated to communicate information about the actual operating experience of selected locations during the year 2000 rollover.

Project Status:

The project has been completed.

Grid Planning & Development - Target 57/30

Contract #: 100-98-001 **Project #:** 13
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: California Institute of Technology : Canadian Electricity Association : Carnegie Mellon University : Cornell University : ESEERCO : Harvard University : Honeywell, Inc. : Howard University : Iowa State University : Michigan Technological University : Mississippi State University : New Mexico State University : P Plus Corporation : Power Technologies, Inc. : PSERC : Purdue Research Foundation : Southern Company Services, Inc. : Texas Engineering Experiment Station : University of Washington
Project Amount: $360,000
Match Amount: $4,489,860
Contractor Project Manager: Dan Sobajic (650) 855-8537
Commission Contract Manager: Don Kondoleon (916) 654-3918
Status: Completed

Project Description:
The purpose of this project is to help grid planners have ample lead-time to prepare for the occasional bulk power transfer. Presently, they are responsible for facilitating hundreds of electricity sales and purchases each day. Bids must be processed in near real time and congestion issues must be resolved on the fly. Grid planning is becoming increasingly complex and labor intensive. This situation is directly at odds with dwindling work forces and loss of experienced personnel and the public demand for lower cost energy. To address this situation, EPRI is providing advanced analysis tools and enhanced communication systems. EPRI's Grid Planning and Development program provides a comprehensive portfolio of technology solutions for coping with the short-, mid-, and long-term planning and design demands of a changing industry. While the industry continues to change, the need to deliver reliable economical power will not. This target delivers planning aids and operator-training tools that improve grid utilization, reduce operating costs, and ensure system security.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing advanced analysis tools and enhanced communication systems which will enhance grid planning in today's high transaction environment while maintaining system security.
- Improving the energy cost/value of California's electricity by improving grid utilization and reducing operating costs through the development and application of advanced tools and communications systems.

Proposed Outcome:

1. Provide software, methods, and information to increase the reliability of the California transmission grid.

Actual Outcome:

1. Software, methods, and information to increase grid reliability.
   - Information was provided that will assist the CA-ISO and California energy companies in designing rates and measuring ancillary services. Detailed information was provided on measuring three ancillary services—regulation, load following, and black start—and on certification testing for black start.
   - Versions 5.0 and 5.1 were released of EPRI's Transmission Reliability Evaluation for Large-Scale Systems (TRELSS) Program, which allows grid planners to

simulate outages and study their effect on system reliability after taking suitable corrective action.

- Version 1.2 was released of Composite Reliability Assessment by Monte Carlo (CREAM), which simulates the composite effects of generation and transmission outages.
- Two software programs were released, and two reports were published on, simulation of complex systems, including a report on prototype intelligent software agents for trading electricity.
- A methodology was produced for evaluating short-term risk in power system planning in the presence of load forecast and fuel price uncertainty.
- Tools were developed to evaluate the annual production cost of electricity as a function of uncertainty in generator availability.
- Version 5.2 was released of EPRI's Small Signal Stability Program (SSSP), which identifies the causes of power system instability and pinpoints the location of technologies to mitigate the problems.
- Version 5.2 was released of EPRI's Voltage Stability Program (VSTAB), which determines areas that are prone to voltage instability.
- Version 5.2 was released of EPRI's Dynamic Reduction Program (DYNRED), which reduces large power system models to lower-order models that retain the characteristics of the original models while significantly reducing the computer time required to perform studies.
- The Common Information Model (CIM) was extended to planning applications, enabling planners to base their studies on operating data and to more closely cooperate with CA-ISO operators.
- Version 5.2 was released of EPRI's Extended Transient Mid-term Stability Program (ETMSP), which allows CA-ISO to conduct mid-term simulations for nonlinear stability analysis of the power system.
- The Off-Line Transfer Capability Evaluation (TRACE) software program was released, and a training workshop was held. This program will allow CA-ISO to increase transmission service revenues by accurately determining the maximum available transfer capability.
- A tri-annual newsletter was published on new software programs and methods for improved transmission grid operation.
- A workshop was held for regional transmission organizations (RTOs) and independent system operators (ISOs), and proceedings of the workshop were published.

Project Status:
The Commission's participation in this target ended December 31, 2000.

Knowledge-Based Customer Metering

Contract #: 100-98-001 **Project #:** 19
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Advanced Systems Associates : Hypertek, Inc. : Plexus Research, Inc. : Arizona State University
Project Amount: $266,500
Match Amount: $1,165,930
Contractor Project Manager: Dave Richardson (650) 855-2331
Commission Contract Manager: Thomas Tanton (916) 654-4930
Status: Completed

Project Description:
The purpose of this project is to provide electricity consumers with intelligent, time-of-use electric meters with built-in communications to enable utilities and their customers to utilize innovative activities such as automatic meter reading and energy utilization analysis. An important part of industry restructuring is customization of service—providing new choices and new benefits to individual clients. Some customers may be attracted by new ways to lower their electricity bills, while others are already demanding premium power quality. Beyond the differentiation of electricity service, new opportunities are also arising for convergence of multiple utility services—including gas, telephone, home security, and Internet access—through a single provider. In each of these areas, more sophisticated customer interface technology will be needed to meet the data collection and communications requirements of the utility service revolution with customers and suppliers benefiting from detailed load and billing information.

New meter technology applications are being developed using the EPRI collaborative research approach to reduce development costs and risks. New products developed during these projects will be available to members for beta testing and at preferential pricing when the product has been commercialized. A prepayment meter is under development to give customers the flexibility of prepaying specific sums, just as telephone cards are now doing. A non-intrusive appliance load monitoring (NIALMS) module will be developed to provide a better understanding of residential energy usage leading to improved time of day pricing service. Tamper detection and research hold out the promise of reducing the number of billing irregularities. This EPRI target also develops market research into new metering service packages. Members will have an opportunity to participate in the research and select the target customers and demographics. Market data and analysis developed during these projects will be available to members for early adoption.

This project supports the PIER Program objectives of:

- Improving the quality of California's electricity by providing advanced meters with the intelligence, flexibility, and communication capability to allow automated meter reading, real-time pricing, and energy management services.
- Improving the energy cost/value of California's electricity by enabling the delivery of value-added electricity services to customers through advanced meters.

Proposed Outcomes:

1. Produce a commercial product—the SE-240 electronic residential meter—which is cost competitive with existing meters on an evaluated basis, while providing an array of additional services.
2. Develop information on residential customers' responses to new types of services made possible by advanced meters and communications systems.

3. Develop information on metering technologies and their applications to provide maximum choice and value to customers.

Actual Outcomes:

1. SE-240 electronic residential meter.
   - Prototypes of the meter were field-tested by 47 utilities, and 19 vendors were engaged in the manufacture of plug-in modules. A technical progress report was published.
   - A prototype meter was released with an internal disconnect switch to be used for remote disconnect to prevent lost revenue.
2. Information on customers' responses to new services.
   - A comprehensive review was published of available information on prepayment metering in North America, including business issues, customer acceptance, regulatory issues, and available products.
   - A report was published identifying new energy services being offered today in residential and commercial markets by electric utilities and energy service companies.
3. Information on metering technologies.
   - Up-to-date information on business issues and technology developments was compiled on the Metering Industry and Product Development web site.
   - Field audits were conducted and a report published on metering revenue losses due to theft, incorrect meter installation, and meter malfunction.
   - Support was provided to national standards setting organizations for open architecture for metering design. The minutes were published of the ANSI C12 Committee Meeting.

Project Status:

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

Opportunities in Networked Home Communities

Contract #: 100-98-001 **Project #:** 14
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Paragon Consulting : EH Publishing : Levey Associates : Connect USA, Hoffman Publications : Macro Research : Web Wizard : Centermore Group, Collaborative.com : North-Atlantic Consulting : Phillips Petroleum Company : Sony : WebTV : Meternet
Project Amount: $487,000
Match Amount: $741,045
Contractor Project Manager: Craig McAllister (650) 855-1095
Commission Contract Manager: Thomas Tanton (916) 654-4930
Status: Completed

Project Description:
The purpose of this project is to help California ratepayers with telecommunication-based consumer electronics and Internet-based service opportunities related to energy usage, Internet billing, meter reading, appliance control, and energy information. California ratepayers need help to sort through the many choices, find current, accurate information and analyses and perspectives sensitive to energy issues - online, interactive and customized to their needs. This Target is designed to provide California ratepayers with these resources. This Target offers convenient and relevant technology surveillance services, coupled with interactive web-based access to specialists and experts inside and outside the utility industry.

Focus- and custom- EPRI analysis is provided in several key areas:

- Protocols and technical standards, converging technologies, and commercial activity in powerline, telephone, radio frequencies (RF) and cable media.
- Products and vendors of commercially available systems, including integration and management services.
- Projects, market assessments, and economic analysis.

EPRI supports implementation of practical solutions in several ways:

- Builder guidelines for new home networking (expanding on the growing service offering begun with HVAC and heat pump guidelines).
- Mobile and Internet connected networked home showcases.
- Energy Network Computer Information Network systems deployment projects.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by informing California energy users of new technologies and services to minimize use and cost of electricity and maximize value to the residential ratepayers.

Proposed Outcomes:

1. Provide market, technology, and business analyses to increase the potential of success of new products and services.
2. Provide Networked Home Centers test-bed facilities to increase likelihood of adoption in California.
3. Provide market, technology, and business analyses of Smart Appliances to bring benefits to California ratepayers.

4. Conduct a Tailored Collaboration entitled "Community Network Demonstration" to evaluate the response of an initial focus group of 100 households to low-cost, non-PC-based, consumer access to relevant energy and public benefit information and services.
5. Conduct a Tailored Collaboration entitled "Linked Infrastructure Security Initiative" to provide workshops and educational materials on designing, managing, and evaluating electronic infrastructure security programs for the energy industry.

Actual Outcomes:

1. Analyses of new products and services.
   - EPRI's Home Automation Technology Surveillance service reviewed more than 1500 news releases, conference and meeting presentations, interviews, and markets analyses.
   - Wrote more than 400 item summaries and collated and organized the summaries in three interest categories.
2. Networked Home Centers.
   - Draft floor plan and budget were developed for a Mobile Home Automation Demonstration Showcase. This mobile "home office" will demonstrate networking via the Internet, in-home utility controls, and multiple, switchable meters.
   - Reports were published on Project Res-IDENT and Community Networks.
3. Analyses of Smart Appliances.
   - Analyses of Smart Appliances were provided through one of the interest categories of EPRI's Home Automation Technology Surveillance service (described above).
   - A report was published on residential gateways and controllers.
4. Plans were developed for a pilot project—the Jefferson Project in Clairemont, California—scheduled to be launched in 2000.
5. Tailored Collaboration on Linked Infrastructure Security.
   - Five workshops were organized and facilitated, included two general program workshops and targeted workshops on development of security policy and procedures, operating systems, and legal issues.
   - Educational materials were published, including a security primer, DCS/PLC primer, SCADA/EMS primer, guidelines document, and an industry strategy paper.
   - A password secured, members-only web site was established for information sharing.

Project Status:

The Commission's participation in this target ended as of December 31, 1999. The Tailored Collaborations ended December 31, 2000.

Power Markets and Risk Management

Contract #: 100-98-001 **Project #:** 8
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: The Brattle Group : L.R. Christensen and Associates : The Northbridge Group : Bechtel Group, Inc. : Energoprojekt Consulting SA : Laurits R Christensen Associates, Inc. : M.S. Gerber & Associates : Marketing Decision Research, Inc. : Pattern Recognition Technologies : Strategic Decisions Group
Project Amount: $733,151
Match Amount: $7,702,872
Contractor Project Manager: Art Altman (650) 855-8740
Commission Contract Manager: Richard Grix (916) 654-4859
Status: Completed

Project Description:
The purpose of this project is to provide a means of understanding risk in the California energy market. Managing risk is a key to competitive electricity prices in California, but traditional analyses cannot accurately reflect the value of resources or risks in today's market. EPRI provides a unique and powerful framework—anchored in modern finance theory—for making decisions with less risk, avoiding huge losses and providing a more stable electricity price environment. EPRI's Electricity Book and other EPRI products extend this tool, and focus on other critical issues, such as forward price curves and ancillary markets. Classes, workshops, and interest groups help Commission staff use all of EPRI's risk management tools quickly and effectively.

This project supports the PIER Program objective of:

- Improving the energy cost/value of California's electricity by reducing the risk associated with large electricity transactions and providing a more stable California electricity market.

Proposed Outcomes:

1. Provide a comprehensive analysis tool to model the California electricity market and the risks associated with the market.
2. Provide tools to value the benefits and risks of energy market transactions.
3. Provide better Forward Curve estimates to improve energy users' decision making.
4. Provide better understanding of ancillary services.
5. Conduct a Tailored Collaboration entitled "Market Pricing and Market Structure Analysis" to identify critical market pricing and market structure issues within California's new competitive electricity market that influence new market entry and have a direct impact on system reliability.
6. Conduct a Tailored Collaboration entitled "Using Dynamic Simulation to Understand Power Plant Construction Cycles" to modify and enhance an existing simulation tool, which will allow the CEC to model the permitting and construction process and thereby obtain new information on the economics and dynamics of cycles in the building of electric generating capacity.

Actual Outcomes:

1. Analysis tool to model the electricity market.
   - Version 1.10 was released of EPRI's Energy Book System (formerly called Electricity Book), an integrated software package that provides the capability for calculating the value of generating units, and for measuring the risks of transactions.

Separate modules are included for pricing and tracking wholesale energy transactions, valuing generation assets, designing retail products, and determining risk exposures.
- Training and user groups meetings were held.
- A report was published on describing commodity prices in the Energy Book System.

2. Tools to value benefits/risks of market transactions.
   - Version 1.10 was released of EPRI's Contract Evaluator software, which is designed to value and price wholesale energy transactions and to calculate exposures to wholesale energy markets.
   - Version 1.20 was released of Contract Evaluator, with enhancements that improve the accuracy and speed of the modeling of price movements for risk management and derivative contract pricing.
   - Version 1.10 was released of EPRI's Risk Manager software, which calculates overall portfolio risk based on exposures, market prices, and price volatilities.
   - Version 1.20 was released of Risk Manager, with enhancements similar to Contract Evaluator described above.
   - Two technical reports were published to assist planners in better measuring risks contained in assets and liabilities, and to understand and analyze the hedging strategies to lower those risks.
   - Five workshops were held on "Value and Risk Management."
   - A workshop was held on "Boom/Bust Cycles in the Power Industry: Power Generation Construction Cycles and Implications of Under- and Over-Building of Natural Gas-Fired Power Plants for Energy Markets and Plant Valuation." Presentations are compiled in a final report.
   - An EPRI Pricing Conference was held.
   - A newsletter was published on the latest EPRI software and tools for power markets and risk management.
3. Forward Curve estimates.
   - A sophisticated suite of tools, methods, and training was provided to assist planners in estimating forward curve price levels and volatilities in California power markets. Chief among these was a report entitled Forward Price Forecasting for Power Market Valuation.
   - Specific methods were provided for estimating process parameters—including natural gas prices and loads—which are key inputs to price forecasting.
   - Follow-up advancements were developed for the Forward Curve tools, including a calculation tool for identifying the marginal cost of power at nodes on the California grid, new algorithms for modeling load uncertainty scenarios, and a prototype model to facilitate application of the FastForward tool.
   - An assembled package was published entitled "Guide to Process Parameter Estimation Tool Kit," which includes a CD and a collection of four stochastic process parameter estimation spreadsheets.
   - More than half a dozen introductory and advanced training workshops and user group meetings were held.
4. Ancillary Services.
   - Measurement and certification tests were conducted at a host generator site. Findings provide insight into understanding methods for measurement and certification, as well as measured values of different ancillary services.
   - A report was produced on key concepts underlying price formation of ancillary services in deregulated markets.

- A workshop was held on ancillary services pricing, market analysis, and operational issues.
- Findings were published from a study entitled "The Gas-Electric Interface—A Regional Analysis," which characterized and interpreted announced capacity additions and determined the extent to which these additions are likely to lead to a net increase in gas consumption.

5. The tailored collaboration has not started, pending approval from the Commission.
6. The modeling tool was delivered and demonstrated to the CEC, and a written summary was presented.

Project Status:
The project has been completed.

Secondary Distribution Impacts of Residential EV Charging

Contract #: 500-98-059
Contractor: Georgia Technology Research Corporation
Contract Amount: $100,000
Contractor Project Manager: Frank Lambert (404) 675-1855
Commission Contract Manager: Mark Rawson (916) 654-4671
Status: Completed

Project Description:
The purpose of this contract is to cost share a collaborative project to analyze the power quality impacts of large single-phase residential loads, such as electric vehicle chargers, computer equipment, appliances, and HVAC to residential secondary distribution (customer-side) systems.

The market penetration of these large single-phase residential loads is a concern to distribution utilities, electric power providers and consumers alike. To the power providers, it is a potential power quality, power delivery, and energy consumption concern. For the distribution utilities and consumers, it is a concern in terms of distribution system reliability, house or site electrical system reliability, and energy costs. Impacts of consumer appliances on the utility secondary distribution system are network externalities. Electricity providers have no regulatory responsibility for network externalities. However, electricity providers do recognize the importance of this issue and are cost sharing this project. The collaborative includes Southern California Edison, Pacific Gas and Electric, Sacramento Municipal Utility District, Virginia Power, Southern Company, and Florida Light and Power.

This project supports the PIER Program objective of:

- Improving the reliability/quality and efficiency of California's electrical transmission, distribution and delivery grid by addressing power quality, power delivery, and energy consumption concerns.

Proposed Outcome:

- Analyze the power quality impacts of large single-phase residential loads, such as electric vehicle chargers, computer equipment, appliances, and HVAC to residential secondary distribution (customer-side) systems.

Actual Outcomes:
The main conclusions of the project based upon utility systems and chargers investigated were:

1. Commercial light-duty on-road EV chargers engineered to National Electric Vehicle Infrastructure Working Council (IWC) guidelines based upon IEC 1000-3-4 do not give rise to excessive voltage total harmonic distortion (THD) on the secondary side of the transformer. Two critical elements that make these guidelines effective are a minimum total power factor of 95 percent and a maximum current THD of equal to or less than 20 percent.
2. The main cause of concern is the overloading of the distribution transformer with widespread use of EV chargers, assuming the chargers meet voluntary IWC guidelines such that voltage THD is not an issue. Still, utility service planning groups should ask for kVa and true power factor values in addition to the kW values for any rectifier or other non-linear load.

Project Status:
Interim results of this project have been presented and published at the North American Electric Vehicle Infrastructure conference in November 1999. A final report was presented at the Electric Vehicle Symposium in October 2000. Project results have also been provided to the IEEE Task Force on Single Phase Harmonics and a summary provided to EPRI for release to the IWC.

Substation Reliability

Contract #: 500-97-012 **Project #:** 15
Contractor: Edison Technology Solutions/Southern California Edison
Project Amount: $215,000
Contractor Project Manager: Moham Kondragunta (626) 815-0507
Commission Contract Manager: Linda Davis (916) 654-3848
Status: Completed

Project Description:
The purpose of this project was to develop an intelligent alarm analysis and diagnostics system, the Alarm Analyzer. The system simplifies thousands of pieces of information and alarms during an emergency condition, such as a regional system breakup due to a fault. In a matter of seconds, the operator is presented with only the relevant and highest priority information on system status and a recommended course of action. This compares to hours or days to do the same manually.

Voice data and command entry is established in control room consoles. During system disturbances, switching and other load and grid operations must be executed quickly and accurately. Speech recognition tools being adapted and evaluated through this project will free the operator from the keyboard to permit data entry and commands by voice. This project improves substation system efficiency, reliability and capacity and reduces operation and maintenance costs. This project helps electrical system operators to provide a much quicker response time during transmission system breakup and disturbance.

The Alarm Analyzer improves the accuracy of control room operator decisions by assisting in quickly identifying the type of fault and accurately identifying its location. This information is essential in reducing the amount of outage time and costs to the users and the utilities. Crews can be dispatched with the correct materials for repairs to the precise trouble location and system reconfiguration can be implemented immediately to restore service through alternate routes.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by reducing restoration and fault analysis time from hours or days to minutes.
- Improving the energy cost/value of California's electricity by reducing operations and maintenance costs.
- Improving the environmental and public health costs/risks of California's electricity by reducing the risk of operation mistakes during power disturbances.

Proposed Outcomes:

1. Complete the initial stage of development of an intelligent alarm analysis and diagnostics system to automatically classify and filter the thousands of pieces of information and alarms generated during an abnormal event on the grid, such as a regional blackout caused by a fault.
2. Investigate the feasibility of the Alarm Analyzer tool.
3. Implement voice recognition technology and evaluate its benefits in the entry of data and commands into a computer or other device in control rooms and other applications.

Actual Outcomes:

1. Southern California Edison (SCE) completed its objectives by developing the Alarm Analyzer tool, implementing voice recognition technology, and conducting successful demonstrations of each.

2. Use of the Alarm Analyzer tool reduced the time required to produce an accurate diagnostic of an event from several hours or days to less than two minutes. These results are based on simulations of actual events occurring at the Dalton Substation.
3. The voice recognition tools evaluated in this project resulted in a productivity increase of at least 200 percent in entering information into a computer file, with an accuracy rate greater than 97 percent. These results are based on a comparison between keyboard entry methods and voice input.
4. Operations and maintenance costs are reduced by improving productivity through data entry and control of computers via voice. Dictating directly to the computer was found to improve productivity by at least 200 percent and greatly simplified multi-tasking for control room operators, line patrols, and office personnel.

Project Status:
The project has been completed.

Systems Stability and Reliability

Contract #: 500-97-011 **Project #:** 6
Contractor: San Diego Gas and Electric Company
Project Amount: $100,000
Contractor Project Manager: Ali Yari (619) 696-2755
Commission Contract Manager: Linda Davis (916) 654-3848
Status: Completed

Project Description:
This project investigated the feasibility and benefits of implementing Flexible AC Transmission System (FACTS) devices on Extra High Voltage (EHV) electricity transmission lines to increase power transfer capability and electricity import capability. The use of Static Condensers (STATCON), Thyristor Controlled Series Capacitors (TCSC) and Static Var Controllers (SVC) were examined in this previous study.

To meet the forecasted future electrical load in California, either additional generation must be installed or import capability must be increased. FACTS technologies help improve power transfer, power quality and system control. FACTS technologies use high-speed, thyristor-controlled devices and advanced control concepts to allow loading lines to their thermal limits without compromising system reliability. This study conducted detailed technical and economic studies to investigate the benefits of FACTS technologies for the SDG&E service territory.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by allowing operators to load lines to their thermal limits without compromising system reliability.
- Improving the energy cost/value of California's electricity by improving the efficiency of the power transfer capacity of the electricity transmission system.
- Improving the environmental and public health costs/risks of California's electricity by improving the power carrying capability of the existing system thereby reducing the need for new transmission lines.

Proposed Outcome:

1. Conduct detailed technical and economical studies to investigate the benefits of Flexible AC Transmission Systems (FACTS) devices located in SDG&E's service territory. The study focus was on the potential benefits of existing and new FACTS devices in improving SDG&E's import capability.

Actual Outcomes:

1. Preliminary studies show that facility overload and reactive power deficiency are the main problems associated with increasing SDG&E's import capability.
2. FACTS technology can be used to mitigate both problems and could possibly increase SDG&E's simultaneous import capability by 300 MW by relieving line overloads and providing dynamic reactive power support.
3. FACTS also could possibly increase non-simultaneous import capability by 250 MW by relieving line overloads and providing dynamic reactive power support.
4. The system transfer capability increases can also be achieved through rearrangement of transmission circuits at lower cost than the FACTS technology.

Project Status:
The project has been completed.

Targets: 64.0/24 Distributed Resources (DR) Information and Tools for Business Strategy Development; 64.3 Distribution Planning Tools for Distributed Resources and 64.4 DR as a Risk Management Hedge in Retail Portfolios

Contract #: 100-98-001 **Project #:** 10
Contractor: Electric Power Research Institute (EPRI)
Subcontractors: Christensen & Associates, Inc. : Daniel Mann Johnson Mendenhall : Edison Technology Solutions/Southern California Edison : Electrical Distribution Design, Inc. : Energy Signature Associates, Inc. : Erin Engineering and Research, Inc. : Hagler Bailly Consulting, Inc. : Materials and Systems Research, Inc. : National Rural Electric Cooperative Association : NEOS Corporation : Ontario Power Technologies : Proton Energy Systems, Inc. : Raytheon Engineers & Constructors, Inc. : Resource Dynamics Corporation : Utility Consulting International.
Project Amount: $596,250
Match Amount: $7,065,337
Contractor Project Manager: Dan Rastler (650) 855-2521
Commission Contract Manager: Jairam Gopal (916) 654-4880
Status: Completed

Project Description:
The purpose of this project is to provide the Commission with information and tools to enable California ratepayers and energy providers to realize the full potential of DR-based business strategies. EPRI involvement in DR research provides the unique access and intelligence necessary to identify new markets niches, improve the use of generation and T&D assets, and evaluate DR-based solutions for commercial and industrial ratepayers and business opportunities for energy providers. The target focuses on creating integrated, dependable, packaged solutions and providing information to better understand the DR market, both locally and globally. This EPRI target provides information to support the planning and deployment of DR projects, analyze DR for retail business applications, understand the impacts of DR on utility distribution systems, and evaluate the integration, management, and control of DR technologies.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by developing generation options that energy providers can utilize to provide unique solutions for peaking power issues, to enhance system reliability (system voltage control), and to assure power quality to their customers.
- Improving the energy cost/value of California's electricity by assisting in the development of innovative distributed resource technologies that can potentially provide lower delivered cost electricity than central station power.
- Improving the environmental and public health costs/risks of California's electricity by assisting in developing fuel cell systems and other environmentally preferred generation technologies to replace traditional central station power.

Proposed Outcomes:

1. Provide strategic information on the DR business environment, trends, technologies, customers, and markets.
2. Compile detailed information to allow analysis of DR for retail business applications.
3. Provide information to assist distribution planners in integrating DR in utility electric distribution systems.
4. Supply information, methodology, and tools to support analysis of DR impacts on electric distribution systems.
5. Conduct market research and provide information on DR markets.

6. Conduct a Tailored Collaboration entitled "Tests and Evaluation of Four Newly Commercialized Distributed Generators in San Diego, CA."
7. Conduct a Tailored Collaboration entitled "Distributed Energy Resources Public Web."

Actual Outcomes:

1. Strategic Information.
   - A quarterly newsletter—*Strategic Intelligence Update: DR Business Developments*—was published on DR applications, business developments, partnerships, demonstrations, regulatory policy, and electrical interconnection and integration research.
   - An online version of *EPRI Distributed Resources Technical Assessment Guide (DR-TAG)* was made available. The web-based Guide includes information on product configurations, technology status, development issues, and prospects for future improvements.
   - Educational tech briefs were published on key DR topics.
   - The 2nd Annual Business Venture Forum, an annual national workshop, was held July 25-26 in San Francisco. It provided a forum for utilities, energy companies, equipment manufacturers, and vendors to discuss the latest technology, market, and policy developments.
   - Advisory Group Meetings were held in February, July, and October.
2. Retail Business Strategies.
   - A report—*Managing Price Risk with Distributed Resources* (1003972)—was published on the potential value of DR as a hedging device for end-use customers.
   - A report—*Framework for Evaluating DR Business Cases* (1003971)—was published on a decision-making framework for analyzing DR-based business opportunities in the context of a retail portfolio, or as a business unit targeting a defined set of customers with identified needs.
3. Integration of DR in Distribution Systems.
   - A report—*Technical Assessment and Evaluation of DR Micro-Grids* (1003973)—was published on the technical and economic feasibility of designing and operating micro-grids.
   - A software tool—*Distributed Resources Integration Assistant: Version 1.0* (1006540)—was developed to provide useful engineering information, calculators, and screening tools to assist those involved with properly integrating DR into the electric power system.
4. DR Impacts on Distribution Systems.
   - A report—*DR Cost Impacts on Transmission and Distribution Systems* (1003975)—was published to assess the economic pros and cons of employing DR technologies when T&D system upgrades are needed.
   - A report—*Siting of DR Units: Process and Issues* (1003974)—was published on the issues and principles involved in the DR siting process and outlines how most tasks can be conducted.
5. Market Research.
   - A report—*Market Research in Residential DR Technologies* (1003976)—was published on results of primary research into issues facing DR in residential markets with a special emphasis on California markets as leaders in accommodating their behaviors to volatile energy markets.
   - A report—*DR Adoption Experience in the Commercial Sector* (1003977)—was published on commercial businesses' experience in using DR technologies and the

extent to which these technologies met the economic and operations experience of these early adopters.

6. Tailored Collaboration—Evaluation of Five Distributed Generators.
   - A demonstration project was conducted, siting new DER products at end-user facilities with the purpose of collecting end-user experiences and better understanding the steps required to site DER devices. A full complement of performance, emission, power quality, and noise tests were also conducted.
7. Tailored Collaboration—DER Public Web.
   - A website containing nearly all the information generated by the EPRI DR targets in the last three years was made available in a well-organized, easy-to-use structure.

Project Status:
The Commission's participation in this target ended December 31, 2000. The tailored collaboratives have been completed.
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USAT MOD-2

Contract #: 500-97-012 **Project #:** 13
Contractor: Edison Technology Solutions/Southern California Edison
Project Amount: $1,000,000
Contractor Project Manager: Bob Yinger (626) 815-0507
Commission Contract Manager: Linda Davis (916) 654-3848
Status: Completed

Project Description:
The purpose of this project was to promote development of the USAT satellite communications system to deliver high-reliability communications for utility supervisory control and data acquisition (SCADA) systems under all types of weather conditions. SCADA systems allow a utility to monitor and control its transmission and distribution system to insure high reliability. Traditionally, communications was accomplished by leased or private telephone lines, microwave, fiber optic cable or radio. The use of satellite communications needs to be very cost effective in remote areas and capable of collecting high speed SCADA data from any location in California no matter how remote. This data would not be available if conventional communications technologies were used.

This SCADA data is valuable in insuring that the highest reliability is maintained for the California transmission and distribution systems by enabling real-time monitoring of system loading and quick execution of control commands during normal and emergency conditions. Because of the system's high reliability and "communications anywhere" capability, it is invaluable during major fires, storms and earthquake emergencies. Communications during these emergencies is valuable in locating problems, assessing damage and returning equipment to service quickly. The ULTRA-NET™ remote terminals are easily installed and can be in service within a few hours to help reduce restoration time after a catastrophic event.

This project supports the PIER Program objectives of:

- Improving the reliability/quality of California's electricity by providing accurate electric grid monitoring information on power supply disruptions.
- Improving the energy cost/value of California's electricity by reducing maintenance costs and restoration time.
- Improving the environmental and public health costs/risks of California's electricity by eliminating the need for service vehicles to visit remote sites on a regular basis. [This will result in a reduction of over 3 million vehicle miles (250 to 500k miles per year) resulting in fuel conservation and a corresponding reduction in environmental pollution].
- Improving the safety of California's electricity by allowing communications to be restored quickly when the infrastructure for other systems has been damaged or during catastrophic events.

Proposed Outcomes:

1. Deliver high-reliability data between SCADA systems of electrical transmission and distribution systems under all types of weather conditions using satellite communications that are cost effective in remote areas.
2. Develop a satellite communications system capable of collecting high speed SCADA data from any location in California no matter how remote to make data available beyond that of conventional communications technologies and enabling real-time monitoring.

Actual Outcomes:

1. The system operated successfully, but more field operation is required before it can be considered a commercial product.
2. To increase the commercial potential of the system, the cost of the remote terminals needs to be reduced since many remotes and only one hub is required in a complete system.
3. Restoration time for communication to remote areas can be greatly improved since conventional restoration can take days, while the restoration of communications with USAT is accomplishable within hours.

Project Status:

The project has been completed.