

CALIFORNIA  
ENERGY  
COMMISSION

**2004 Annual Review of the PIER Program  
Volume 6 – Energy-Related Environmental  
Research Project Summaries**

**STAFF REPORT**

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

## **Adaptation to Climate Change for California’s Water System: Societal Layers of Adaptations and Impacts**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-019

**Contractor:** University of California, Davis

**Project Amount:** \$250,000

**Contractor Project Manager:** Jay Lund (530) 752-5671

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### **Project Description:**

The purpose of this project is to enhance the methods and models used to estimate the potential impacts of climate change on hydropower generation, agricultural production, water supplies, and flood control. Researchers will also test the practical efficiencies of adaptation suggested by a statewide water system optimization model (CALVIN) with a more detailed regional simulation model (CALSIM).

Climate change could impact the water delivery system and hydropower generation in California significantly. A PIER study suggests that by the end of the century, the annual amount of water stored as snow in California could be half of its historical level. This decline appears under a wide range of modeled climate scenarios.

A previous PIER project supported the enhancement and use of the CALVIN model for an exploratory evaluation of the potential impacts of climate change on water resources—an effort that provided very useful insights. CALVIN’s modeling encompasses most of the water delivery and storage system in the State. It suggests optimal adaptation measures, but it does not incorporate the social and political feasibility of implementing those measures. As an example, the current version of the CALVIN model cannot simulate the plausible scenario of regional water markets. Under this project, researchers will enhance the model to include more in-depth policy option analyses.

Researchers will also test the optimal adaptation strategies suggested by CALVIN running CALSIM—a simulation model used by the California Department of Water Resources (DWR)—to further evaluate the adaptation measures suggested by CALVIN. CALSIM complements the output of CALVIN by investigating which water rules must be changed to achieve the optimum solution suggested by CALVIN.

Both CALVIN and CALSIM simulate conditions for a given future year, without modeling the evolving conditions from the present to that year. However, for climate change analysis, it is highly desirable that models be able to simulate evolving transient conditions such as climate change and urban growth. This project will enhance the CALVIN model to allow for these types of simulations.

Finally, the CALVIN model will be enhanced to dynamically account for the effect of sea level rise on water resources in California.

Both PIER and DWR staff will serve in a technical committee to guide this project and ensure the value and usefulness of the research.

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

- Providing environmentally sound energy services by improving scientific understanding of the potential impacts of climate change on California’s water resources and other important sectors.

**Proposed Outcome:**

1. This project will develop an enhanced CALVIN model that: (1) incorporates the social and political feasibility of implementing optimal adaptation measures for California’s water system, (2) is able to model evolving conditions from the present to future years, and (3) can dynamically take into account the effect of sea level rise on water resources in California. These enhancements will enable researchers to model a variety of future scenarios more accurately, and provide decision makers with much more realistic information on which to base policy.

**Project Status:**

Work on this project began on January 1, 2004. No reports are expected in 2005. Most of the work has been concentrated in model development and testing.

**Advanced Energy Technology Options for California Within the Context of National and Global Systems**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-031

**Contractor:** Pacific Northwest National Laboratory

**Project Amount:** \$750,000

**Contractor Project Manager:** Jae Edmonds (301) 314-6749

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

**Project Description:**

The PIER program has created a program, centered at the University of California at Berkeley, on the economics of climate change and greenhouse gas (GHG) mitigation strategies in California. The role of various technologies in providing cost-effective means of GHG mitigation is a significant analytical issue for this effort. The research conducted under this work authorization will provide an enhanced knowledge base for analyzing technologies by carrying out complementary national and international-level analysis that can inform and be articulated with the California-focused analysis currently underway with PIER support. The Global Technology System Program (GTSP) is a collaborative research partnership on technology, energy, and climate change, organized and managed by Pacific Northwest National Laboratory (PNNL). The Phase I activities have encompassed development and analysis of broad energy and technology scenarios. The Phase II activities, to which PIER would contribute under this Authorization, will focus on in-depth analyses of specific technologies or technology categories. The following paragraphs summarize the proposed activities.

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

- Improving the environment, public health, and safety of California’s electricity by looking at the potential long-term evolution of the national and international energy systems.

**Proposed Outcomes:**

1. Development of Protocols for “Deep-Dive” Analyses: The analytical core of the work will be so-called “deep-dive” analyses of specific technologies and/or technology categories. This terminology refers to the in-depth technical and scenario analysis of individual technologies in the context of the evolution of national and international energy systems. To ensure the maximum benefit for California-related application, detailed protocols for these analyses will be created by the contractor and approved by PIER prior to the commencement of the actual research. Protocols will be developed and approved for the technologies of particular interest to PIER: renewable electric power generation, carbon sequestration, and energy efficiency.
2. Advanced Technology Options Analyses (“Deep-Dives”): The technical work will be organized in the following sequence. First, detailed cost and performance information on specific technologies will be obtained. Second, this information will be embedded in one or more PNNL scenario simulation models, and this model representation will be coordinated with California-focused modeling underway at U. C. Berkeley. Third, detailed technology-specific and model-based scenario design will be conducted, with emphasis as appropriate on regional disaggregation and, as in the previous step, coordination with UC Berkeley. The fourth step is the model-based determination of appropriate portfolios of R&D for technology development in renewables, energy

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efficiency, and carbon sequestration, and the potentials for R&D to accelerate development and diffusion of these technologies and lower their cost.

**Project Status:**

The project is expected to be completed by March 30, 2007.

## Air Quality Research Program Administration

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-026

**Contractor:** University of California, Riverside

**Project Amount:** \$3,512,279

**Contractor Project Manager:** James Lents (909) 781-5742

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Active

### Project Description:

The purpose of this project is to provide an expert team for continued management of existing air quality research contracts, and to develop an air quality research program that provides technical, fiscal and contractual administration, while providing the Commission oversight at critical decision points. It will develop a broad base of research concerning the direct and indirect urban, regional and indoor air quality impact of present and future electricity generation and use in California and distribute information on relevant research.

The first project under this program is life-cycle analyses of distributed generation (DG). The purpose of the DG life-cycle analysis project is to develop information that can be used to better understand and quantify the environmental and health impacts of DG compared to existing central power plants and to identify how to reduce impacts that are determined to occur from the use of DG.

More than 2,000 megawatts of electrical generation capacity in California is classified as DG equipment (*Distributed Generation Strategic Plan*. P700-02-002. CEC. Sacramento, Calif. 2002). Distributed generation technologies can offer benefits such as improved electricity reliability and power quality, competition against central plant generation, short installation time, and the ability to generate electricity in remote locations. For these reasons, the California Public Utilities Commission and the Energy Commission are encouraging the use of DG, and the Energy Commission's strategic plan outlines activities that would increase the implementation and use of DG in the State.

However, as a group, DG technologies are at widely differing states of development and the health and environmental impacts of these technologies is not well understood. Diesel engines, for example, are readily available today in a wide range of sizes, although emissions control technologies for diesel units are not fully mature, so some emissions from these systems are typically quite high, making them unfeasible as a primary power source. At the other end of the spectrum, advanced fuel cells are expected to be highly efficient, low-polluting electricity generators, but may not be commercially available at competitive prices for years. In addition, most combustion DG technologies are less efficient than state-of-the-art, combined-cycle, natural gas power plants (the current generation technology standard for baseload power plants), and their emission controls are less mature. The desire for a thoughtful deployment of these technologies was stressed in California Senate Bill 1298, which states: "It is in the public interest to encourage the deployment of distributed generation technology in a way that has a positive effect on air quality [SB 1298, Bowen and Peace, Chapter 741, Statutes of 2000, Section 1(e)]."

This project will compare the cradle-to-grave environmental impacts and economic costs of existing and emerging distributed generation (DG) technologies to a typical combined cycle natural gas power plant being built in California (including transmission and distribution). The project will also build upon the project by University of California at Irvine (UCI) that developed DG penetration scenarios for the South Coast Air Basin (SoCAB) for 2010 and estimated air

quality impacts. Deployment scenarios will be developed for two future years and three emerging markets for the SoCAB. DG scenarios will be developed to represent various emissions portfolios that would characterize DG deployment in the California Central Valley (an area with very different industry, population, geography and meteorology than the SoCAB) and estimate the potential impacts of different DG deployment scenarios on ambient air quality. Also, a method will be developed to estimate the near field impact of DG emissions located in urban areas. This method will be applied to estimate the impact of realistic emission scenarios in the South Coast Air Basin.

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

- Improving the environmental, public health, and safety of California’s electricity by better understanding and quantifying 1) the impact of existing and new electric power production technologies have on air quality and identifying how to reduce the impacts, 2) the relationship between indoor environmental quality (IEQ) and energy use, providing a basis to improve indoor energy efficiency without adversely effecting IEQ.
- Improving the reliability, quality, and sufficiency of California’s electricity by increasing the ability of California to generate adequate electricity supplies. Better understanding impacts of new power generating facilities and community concerns may speed their installation and increase the ability of California to generate adequate electricity supplies.

**Proposed Outcomes:**

1. Improve air quality modeling for California and improve assessment of the impacts of existing and future power production on the air quality in California to better understand what controls and regulations are needed to provide for better air quality within the State.
2. Develop information that will provide a better understanding of the relationship between indoor air quality and energy use to provide guidance for achieving both improved indoor energy efficiency and improved indoor air quality.

**Project Status:**

This program began in April 2004 and is on schedule.

## Bioassessment for Hydropower Evaluations

**Contract #:** 500-03-017

**Contractor:** Department of Fish and Game

**Contract Amount:** \$774,414

**Contractor Project Manager:** James Harrington (916) 358-2862

**Commission Contract Manager:** Joe O’Hagan (916) 653-1651

**Status:** Active

### Project Description:

The purpose of this project is to develop tools to evaluate and monitor the effects of hydropower operations on aquatic ecosystems. Hydropower operations may adversely affect water quality and aquatic habitat through a variety of mechanisms, including alteration of water temperature, timing of flows, sediment loads and discharge volume.

The California Department of Fish & Game (CDF&G) developed the first California Stream Bioassessment Procedures (CSBP) in 1993 to analyze the composition and diversity of certain aquatic species or communities. The CSBP analyzes the macroinvertebrate communities of streams to determine the impacts on the ecosystem of temperature, flow, sedimentation, pollution, and other factors. *Benthic macroinvertebrates*—invertebrates that occupy, for at least a portion of their life cycle, the bottom substrates of freshwater habitats—have proven to be especially useful in evaluating water quality. Hydropower relicensing by the Federal Energy Regulatory Commission (FERC), the State Water Resources Control Board and CDF&G have required bioassessments be conducted using the CSBP protocols. Over the next 15 years in California, more than 50 hydropower projects (representing over 4,000 megawatts of installed capacity) will undergo FERC relicensing, and bioassessments will be required as part of each re-licensing process.

Bioassessments may be useful in diagnosing the specific mechanisms that cause degradation of an aquatic community up or downstream of a dam, because they identify long-term problems better than simple physical and chemical measurements do. Other measures of biological integrity (such as measurement of fish populations) are very expensive and are not necessarily indicative of overall ecosystem health.

This project is evaluating hydropower operation factors and existing CSBP data to identify correlations between the two. Researchers are conducting field and laboratory studies that will collect new data to further test potential correlations. The project’s overall goal is to identify benthic macroinvertebrate response to specific hydropower operation factors.

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

- Developing cost-effective approaches to evaluating and resolving the environmental effects of energy production by determining correlations between hydropower operation and CSBP data that will allow planners, researchers, and operators to identify issues chiefly attributable to hydropower. Correlation of benthic macroinvertebrate community response to hydropower operation will provide a long-term indicator for the ecological health of aquatic environments affected by hydropower operation. Research results will help state and federal agency staff, hydropower operators and other stakeholders to assess hydropower operation impacts to aquatic ecosystems. This research will also refine protocols for future bioassessment work addressing hydropower operations and the resulting effects on aquatic resources.

**Proposed Outcomes:**

1. Perform a statistical analysis of existing information collected for hydropower projects using the CBSP in an effort to identify potential correlations between hydropower operation and macroinvertebrate species and communities.
2. Conduct field and lab work to collect additional information to establish and confirm correlations.
3. Develop protocols for future bioassessment efforts addressing hydropower operations.

**Project Status:**

Work began on this three year project in January 2004. The project is on schedule and within budget.

## **Continuing Climatic Data Collection, Analyses, and Modeling**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-025

**Contractor:** University of California, San Diego - Scripps Institute

**Subcontractors:** Western Regional Climate Center : University of California, Davis : University of California, Santa Cruz : United States Geological Survey : Lawrence Livermore National Laboratory

**Project Amount:** \$3,535,000

**Contractor Project Manager:** Dan Cayan (858) 534-4507

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### **Project Description:**

This work authorization will allow Scripps to continue their research program designed to improve our scientific understanding of the potential changes of climate in California. Several new avenues of research will be pursued, such as the study of the effect of land use changes on climate. This work also includes some work in cooperation with scientist from Lawrence Livermore National Laboratory and the National Center for Atmospheric Research to perform an exploratory but rigorous climate detection and attribution study to estimate if a climate change signal is already discernible in California.

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

- Improving the environment, public health, and safety of California's electricity by improving our scientific understanding of the potential changes of climate in California.

### **Proposed Outcomes:**

1. Continue the operation and enhancement of the Climate Data Archive.
2. Install additional monitors in remote areas of California.
3. Perform additional analyses of climate variability.
4. Adopt a land surface hydrologic and energy balance model for the California region and perform model simulations replicating historical conditions.
5. Perform a climate change detection and attribution for California.

### **Project Status:**

The project is on schedule and is expected to be completed by June 1, 2007.

## Dynamic Ecosystem Modeling for California

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-024

**Contractor:** Conservation International

**Project Amount:** \$596,778

**Contractor Project Manager:** Lee Hannah (202) 912-1360

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### Project Description:

Under this project, the research team will develop a new ecosystem model for California based on the BioMove model. This model will be fully tested and parameterized for climate change predictions in six target ecosystems in the State.

This project will start overcoming some of the key limitations of existing vegetation dynamic models by considering additional ecological variables (e.g. land use characteristics, age and spatial structure of vegetation, dispersal rates and modes of different species, and invasive species). The new model will also consider the interaction of plant and animal species as well as the influences of the abiotic environment when modeling climate change impacts.

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

- Improving the environment, public health, and safety of California's electricity by overcoming some of the key limitations of existing vegetation dynamic models by considering additional ecological variables.

### Proposed Outcomes:

1. Develop a new ecosystem model for California.
2. Acquire all the input data needed to run the California model.
3. Test the model and perform a preliminary estimation of the impact of climate change on the six selected ecosystems.

### Project Status:

The researchers are associated with Stanford University, UC Davis, UC Santa Barbara, the National Botanic Institute of South Africa, and others. This group had a week long planning meeting in the summer of 2004. The data gathering process has also started. This included plant occurrence data, plant life history data, bird phenological data, climatologies and GIS layers to populate the biological models. These data collection efforts will be ongoing over the next two years of the project.

The project is on time, and the expected completion date is March 31, 2007.

## Enhanced Climate and Hydrological Monitoring for California

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-027

**Contractor:** Desert Research Institute

**Project Amount:** \$399,918

**Contractor Project Manager:** Kelly Redmond (775) 674-7011

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### **Project Description:**

Understanding and projecting changes in California's climate is critically dependent on building and maintaining a network of environmental observations in key areas of the State. The objectives of this project are two-fold: (1) make measurements that help us better interpret the enormous volume of existing climate data and (2) extend the coverage of climate quality records to undersampled climates, such as the high mountains which furnish much of our water, the coastlines where large populations live astride sharp climate boundaries that greatly affect energy consumption, and other climate regimes in the State.

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

- Improving the environment, public health, and safety of California's electricity by increasing our understanding of California's climate.

### **Proposed Outcomes:**

1. Assess the need and recommend sites.
2. Install the monitoring stations.
3. Receive and evaluate the data.
4. Maintain the stations and calibrate the instrumentations.

### **Project Status:**

The researchers submitted a document with a list of suggested sites. The monitors will be installed in 2006. The final report for this project will be available in September 30, 2008.

## Hydropower Environmental Issues (EPRI Program #58)

**Contract #:** 500-02-028 **Project #:** 18

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

**Project Amount:** \$15,000

**Contractor Project Manager:** Doug Dixon (804) 642-1025

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Active

### Project Description:

The purpose of this project is to deliver up-to-date information, effective tools, and practical guidance for assessing and minimizing environmental impacts and balancing often-conflicting stakeholder demands while maximizing hydropower generation. Project activities provide information, guidance, and tools for environmental analysis and operational decision-making in response to regulatory requirements and policy initiatives concerning fish passage (upstream and downstream), in-stream flow restoration and protection, turbine entrainment and mortality, water quality, sediment management, and project decommissioning. All work addresses issues regarding maintaining and improving water availability and quality, maintaining and strengthening portfolios of generation options, and managing ecological assets. This project provides scientific information to support hydropower operations, permitting, and re-licensing decisions.

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

- Improving the environmental and public health cost/risks of California's electricity by providing science-based assessments and information to assist in the development of balanced strategies for hydropower generation and the management and protection of aquatic resources.

### Proposed Outcome:

1. Provide facility owners and other stakeholders tools and methodologies for meeting the demands of existing and new environmental requirements and helping them to minimize negative effects on aquatic resources while sustaining hydropower operation.

### Actual Outcomes:

1. Fish Passage and Protection Management. Technical Update 1- Informal Report, *Anadromous Fish Restoration: Evaluation of a Modified Alaska Seep-pass Ladder as a Lower-Cost Alternative to a Denili Fish way*. Completed December 2004. EPRI Product # 1008484.
2. Fish Passage and Protection Management. EPRI Tech. Research Newsletter, *Fish Passage and Protection Management*. Completed June 2004. EPRI Product # E218122. EPRI Newsletter distributed on a quarterly basis.
3. Fish Passage and Protection Management. Technical Update 1, *Fish Passage Manual Chapter Updates*. Submitted March 2004 for delivery 3/31/05. EPRI Product # 1008482.
4. Fish Passage and Protection Management. Technical Update 1, Informal Report, *Research on Turbine Leading Edge Blade Shapes Favorable to Fish Survival*. On schedule for delivery 3/31/05. EPRI Product # 1009754.

### Project Status:

The project was completed in December 2004.

**Life-cycle Assessment of Wildland Biomass for Electrical Power: Modeling Benefits, Costs, and Environmental Impacts**

**Contract #:** 500-03-019

**Contractor:** USDA Forest Service, Sierra Nevada Research Center, Pacific Southwest

**Subcontractors:** TSS Consultants

**Contract Amount:** \$1,999,995

**Match Amount:** \$254,911

**Contractor Project Manager:** Mark Nechodom (530) 759-1706

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Active

**Project Description:**

The purposes of this contract with USDA Forest Service are to:

- 1) Construct a life cycle assessment (LCA) model of the use of by-products generated from in-forest fuels treatments for biomass power.
- 2) Evaluate thinning treatment effects on forest health and watersheds and help determine how best to mimic natural fire regimes.
- 3) Determine future research needs.

As California’s Renewable Portfolio Standard (RPS) requires more renewable electricity to be produced, biomass is expected to play a significant role in generation. It is crucial to ensure that it provides the maximum environmental benefits to the State. The use of wildland biomass as an energy source can improve air and water quality, provide preferable disposal options, improve forest health, and help reduce catastrophic wildfires. However, these environmental benefits are not yet realized in the economies of scale in the current market. Costs of fuel collection, transport, and processing—as well as the smaller capacity of biomass facilities in comparison to state-of-the-art power plants—prevent biomass generation from being cost competitive. Yet, when the collateral environmental benefits *are* figured into economic analyses, biomass generation can be cost-competitive with traditional types of energy production.

The use of biomass fuel from in-forest fuel treatments to achieve environmental benefits is the least understood of the environmental economic analyses, due to incomplete data and analyses. In addition, prescriptions for thinning forests and wildlands to reduce fuel loading are not well defined. Determining how much biomass needs to be removed from those ecosystems to achieve environmental and economic benefits and improve forest health is key to resolving that controversy. The effect of that resolution could be substantial—the volume of wildland biomass (estimated at 16 to 30 million bone dry tons annually) would be about four to eight times the current biomass volume from all sources currently consumed for biomass power production in California.

The Forest Service will engage expertise from the Pacific Southwest Research Station, the Energy Commission, the California Department of Forestry and Fire Protection (CDF), the California Department of Fish and Game, the California Air Resources Board, academic institutions, TSS Consultants, and industry and environmental groups to:

1. Critically review and synthesize existing studies to determine what research is necessary to populate the economic and environmental modules of the life-cycle assessment model.
2. Develop a life-cycle assessment model to calculate the impacts and benefits of fuels treatments for use in biomass power generation in California.
3. Develop a specific in-depth research portfolio to fill critical gaps in the model.

4. Produce and analyze a series of California-specific environmental and economic policy scenarios using the finalized model.

To help ensure that the results of this work will be applied by stakeholders, the Forest Service will solicit input from policy and technical experts.

Once the LCA model is developed, researchers will produce and analyze a series of economic and policy scenarios about the use of wildland biomass for power generation in California. The scenarios will reflect a range of policy options, as well as a range of biomass removal and biomass power technologies that reflect the diverse and site-specific ecosystem issues present in California.

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

- Improving the energy cost/value of California's electricity by providing research and a model that will help the State's decision makers analyze the costs, benefits, and trade-offs inherent in the use of wildland biomass for electrical generation.
- Providing environmentally sound electricity by being able to model different environmental scenarios for different regions. Decision makers will be better able to decide whether the benefits of harvesting and using biomass in a particular area outweigh the impacts to the biota that inhabit those forests.
- Providing reliable electricity by promoting wildland biomass as an environmentally safe renewable energy source. California has shown that its capacity for biomass production far exceeds that which is currently being employed. As the State's electricity producers explore renewable generation options to meet the State's RPS, biomass generation provides a near-term alternative. It also helps diversify the State's generation resources at a time of rising natural gas prices.

**Proposed Outcome:**

1. Develop a life-cycle assessment (LCA) model that will help stakeholders assess the environmental and economic life-cycle impacts and benefits of using forest fuels treatment by-products for biomass power.
2. Help determine the best thinning treatments to promote forest health, which will help promote the environmentally acceptable, scientifically sound production of energy resources from California's wildlands.

**Project Status:**

A prototype model and reports on forest treatments research needs will be available in 2005. A series of California-specific environmental and economic policy scenarios using the finalized model and the results on site-specific forest ecosystems studies will be completed by 2007.

**Physical/Statistical and Modeling Documentation of the Effects of Urban and Industrial Effects of Urban and Industrial Air Pollution in California**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-032

**Contractor:** Woodley Weather Consultants

**Project Amount:** \$299,650

**Contractor Project Manager:** William Woodley (303) 979-7946

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

**Project Description:**

Most atmospheric investigations of climate change have focused on the role of greenhouse gases in global warming and on the role of atmospheric aerosols in cooling the atmosphere by reflecting some of the incoming solar radiation back into space. Recently researchers have been focusing on black carbon as a potential global warming agent. Much less is known, however, about the impact of aerosols from urban and industrial air pollution on precipitation. The precipitation forming processes in clouds depend to a large extent on the presence of aerosols, namely cloud condensation nuclei (CCN) and ice nuclei.

A wealth of newer evidence now suggests that CCN pollution does act to decrease precipitation. It is now believed that air pollution suppresses precipitation by inhibiting the coalescence of cloud droplets into raindrops and by preventing the formation of ice particles and cold precipitation processes in clouds. A likely explanation is that aerosols from air pollution serve as small CCN that form large concentrations of small cloud droplets.

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

- Improving the energy cost/value of California's electricity by studying the effect that aerosols have on precipitation, which in turn affects hydroelectric generation.

**Proposed Outcomes:**

1. Find out what areas of California are affected by aerosols and under what circumstances this effect is more pronounced. The research group, which includes Prof. Rosenfeld from Israel, has recently documented a reduction in precipitation in high elevations downwind of urban areas in California and Israel. In California, precipitation levels would have been about 16 percent higher from historical levels. This reduction has not been obvious to water managers because, on average, precipitation has not changed in the last 50 years but it would have been higher without the effect of aerosols. The researchers will use 3 years of satellite data using a technique developed by Prof. Rosenfeld to find out what areas of California are affected and under what circumstances this effect is more pronounced. This study will be complemented with the use of an advanced meteorological model, which will include a new sub-model developed to explicitly model the effect of aerosols on cloud formation and precipitation.
2. Advance our understanding of the effects of air pollution on precipitation patterns and on stream flow in the State of California. This project will be overseen by a Technical Advisory Committee (TAC) comprised of technical staff from the California Department of Water Resources, the California Air Resources Board, the U.S. Bureau of Reclamation, Scripps Institute of Oceanography, the Western Regional Climate Center, and the California Energy Commission.

**Project Status:**

The project is expected to be completed by December 31, 2006.

## **ENV Active Projects from Previous Years**

## **Air Quality Impacts of Distributed Generation**

**Contract #:** 500-00-033

**Contractor:** University of California, Irvine

**Contract Amount:** \$698,689

**Contractor Project Manager:** G. Scott Samuelsen (949) 824-1999

**Commission Contract Manager:** Philip Misemer (916) 654-4552

**Status:** Active

### **Project Description:**

The purpose of this project is to determine the regional and overall environmental impacts of widespread distributed generation (DG) implementation in southern California. Researchers will develop and analyze several DG implementation strategies that represent both realistic market penetration and bounding case studies for the year 2010 and evaluate the associated air quality impacts of using these technologies. This work will also determine whether accurate accounting of aerosol dynamics is required for modeling air quality in Southern California and whether the accuracy of state-of-the-art air quality models is sufficient to capture the impacts of DG. Researchers will share the findings with regulatory agencies to facilitate the development of future control strategies.

The application of distributed generation technologies to the California market could potentially reduce overall generation emissions and bring about important benefits in overall electricity reliability, cost, and power quality. In 2001, the California Public Utilities Commission developed the \$125 million-a-year Self-Generation Incentive Program to give cash incentives to California business and individuals that begin using DG technologies in the State. Moreover, the Energy Commission projects that between 300 and 400 MW of DG units will be installed in the State in the near term. However, moving from central generation units to localized distributed generation facilities would result in significantly different emissions profiles, with increased and widely dispersed stationary source emissions closer to residential areas.

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

- Improving environmental and public health costs/risk by enabling researchers to determine how DG technologies should be implemented to reduce environmental impacts by examining various DG implementation scenarios.
- Improving the reliability/quality of California's electrical system by increasing the ability of California to generate adequate electricity supplies. Identifying how these technologies should be operated as part of the State's generation mix may speed their installation and increase the ability of California to generate adequate electricity supplies.

### **Proposed Outcomes:**

1. Establish Distributed Generation Scenarios to represent various emissions portfolios that would characterize DG deployment in 2010 and future years.
2. Produce a modeling strategy that can adequately estimate the impacts of DG resources and coordinate with previous and current CARB studies.
3. Improve particulate matter (PM) simulations by increasing the level of physical/chemical detail in the aerosol modules.
4. Qualitatively estimate the potential impacts of different DG deployment scenarios on efforts to attain ambient air quality standards for ozone and PM.
5. The current effort seeks to address these issues and collaborate with the South Coast Air Quality Management District and the CARB to assess the potential impact of DG on air quality.

**Project Status:**

A systematic method to characterize DG implementation was developed and applied. This generalized method can be used in any region or locale. More than 30 DG implementation scenarios were developed and successfully simulated using a state-of-the-art three-dimensional computational model to determine the potential air quality impacts of DG. The detailed air quality simulation results suggest that DG could have both positive and negative impacts on localized ozone and particulate matter 2.5 micrometers in diameter and smaller ambient concentrations. All realistic DG implementation scenarios have negligible impacts on overall basin compliance with ozone and particulate matter standards that include only DG that abides by the strict air pollution limits of California Air Resources Board and South Coast Air Quality Management District. Nonetheless, observable impacts of DG may affect local air quality and may be more significant in later years. Results from the current project will be helpful in establishing policies that affect DG deployment. The final report will be available in the summer of 2005.

## Alternative Cooling Program

**Contract #:** 500-02-014 **Work Authorization #:** E2I-WA-104

**Contractor:** Electricity Innovation Institute

**Subcontractors:** John Maulbetsch

**Project Amount:** \$800,000

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Active

### Project Description:

The goal of this effort is to establish a comprehensive, multi-year initiative to fund research that addresses barriers to the use of water conserving cooling technology and non-freshwater cooling water sources for power production in California and elsewhere.

The need for adequate and economical electric power sometimes conflicts with the need to conserve and allocate the State's scarce water resources. In California, a significant portion of the water used for power generation is fresh, often potable, water. Power generation consumes 235,000 acre-feet (about 76.6 billion gallons) of California's water supply per year, with most of that water being used for wet cooling technologies at power plants. On average, a 500-megawatt (MW) combined-cycle power plant using wet cooling technology requires three million gallons of cooling water per day—enough to satisfy the daily water demands of more than 13,100 people.

For this project, PIER Environmental Area (PIER-EA) and Electricity Innovation Institute (E2I) have assembled a technical advisory committee (TAC) consisting of agency, university, and/or industry representatives. Under the guidance of the TAC, PIER-EA and E2I developed research selection criteria and released a request for proposals to address advanced power plant cooling research. Ten proposals were submitted and based upon the comments of the TAC, three projects were funded. Two of these projects are addressing the effects of wind conditions on the performance of air-cooled condensers (dry cooling technology). The first project is using computational fluid dynamic modeling to identify how wind affects air flow intake and recirculation as well as fan performance for air cooled condensers. The other study is looking at ways to mitigate wind impacts on air cooled condenser performance.

A national research conference on water conserving cooling technology and alternative sources of cooling water is being funded through this program as well. This conference will be held in Sacramento on June 1<sup>st</sup> and 2<sup>nd</sup>, 2005.

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

- Improving the environment and public health cost/risk of California's electricity by using technologies that can considerably reduce fresh water use, leaving more fresh water in the natural environment or for delivery to customers.
- Improving the Energy Cost/Value of California's Electricity by identifying ways to increase the output of power generators while using less water, enabling them to deliver more electricity to the grid and increase the reliability of California's electrical system. The study results may also enable power plants to be built closer to the end-users in areas where fresh water is in short supply.
- Improving the Safety of California's Electricity by reducing potential adverse health and environmental effects associated with wet cooling, such as surface and groundwater contamination from spills and wastewater discharge, Legionnaire's Disease, storage and

handling of hazardous chemicals and emissions from volatile chemicals, such as trihalomethanes (THM).

**Proposed Outcomes:**

1. Define the effect of water consumption in power generation plants on plant performance, capacity and cost of electricity.
2. Identify opportunities for minimization of water use.
3. Identify state-of-practice operating parameters for degraded water resources to encourage its use.
4. Identify state-of-practice design and operating experience for zero liquid discharge systems and practices.
5. Conduct the research necessary for the development or improvement of advanced devices and processes that will maintain or improve plant performance and cost while reducing water requirements.
6. Demonstrate the effectiveness of these advanced approaches.
7. Encourage the commercialization and use of preferred technologies.

**Project Status:**

This three year project began in the fall of 2003 with the formation of the technical advisory group. The project released a request for proposals in the second quarter of 2004. Ten proposals were received and three are being funded. The three funded projects include:

- The use of computational fluid dynamic techniques to model the effects of wind on air-cooled condenser performance.
- Development of mitigation measures to reduce the effects of wind on air-cooled condensers.
- The use of sea water for re-circulating cooling in California.

The project is also holding a conference on recent research on the use of water conserving cooling technology and alternative sources of cooling water in the second quarter of 2005.

## Assessment of Carbon Sequestration Potential in California Agricultural Soils

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-005

**Contractor:** University of California, Davis

**Subcontractors:** Kearny Foundation

**Project Amount:** \$250,000

**Match Amount:** \$498,367

**Contractor Project Manager:** Kate Scow (530) 754-9668

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### Project Description:

The purpose of this project is to study the carbon sequestration opportunities of California agricultural soils, to better understand the sequestration rates and potential for those soils under various management techniques.

Fossil-fuel combustion providing electricity to California is responsible for about 28% of California's total carbon dioxide (CO<sub>2</sub>) emissions, which contributes to atmospheric warming and climate change. Effects to California could include altered rainfall and snowfall patterns that result in seasonal water shortages and an increased occurrence and intensity of wildfires, among others. Spring watershed runoff has already decreased nearly 12% in some California river systems. This decrease threatens hydropower production, which produces approximately 20% of electricity generated in-State and is a key source of electricity in the spring and summer.

One strategy for reducing California's contribution to atmospheric carbon levels is carbon sequestration, which is the net removal of CO<sub>2</sub> into long-lasting carbon repositories. Carbon is stored in plant tissues during everyday growth and maintenance, so atmospheric CO<sub>2</sub> can be reduced by: (1) preventing carbon release from natural sources into the atmosphere, and (2) removing carbon from the atmosphere by increasing the amount of carbon stored in vegetation, and ultimately, soil.

California agricultural lands offer a particularly abundant opportunity for carbon sequestration, since approximately 11% of the State's land is used for agriculture and much of this land is managed extensively. Additionally, many years of intensive crop production have left most California soils well below their carrying capacity for carbon, therefore, they have great carbon storage potential. However, the State's vast diversity of soils, crops, topography, rainfall, and microclimates prevent a "one-size-fits-all" approach to carbon sequestration, so research must identify the most effective and economical techniques for sequestration in each application and region.

This project is being conducted in two phases. In the first phase, the research team is reviewing existing literature on agricultural soil carbon sequestration, identifying data and data gaps for evaluating such carbon sequestration in California, and selecting a California county for field study. In the second phase, researchers will employ the knowledge gained in the first phase to: (1) conduct a pilot study that will assess current rates of carbon sequestration within the selected county, (2) assess the potential for increased carbon sequestration with the adoption of conservation practices, and (3) provide locally relevant estimates and decision-making tools that can be used to evaluate which of the management strategies identified for that region has the best potential to sequester carbon. Researchers will adapt existing models or develop new models to predict carbon sequestration and greenhouse gas emissions in California crops.

Part of this effort will develop supply curves for an agricultural county in the State. The supply curves will illustrate the amount of carbon that could be sequestered in that county by using various management practices, and will also show the associated costs for each practice, in dollars per ton of CO<sub>2</sub>. In addition, this project will identify the impacts of these practices on the quality and quantity of crops and evaluate potential secondary effects, both positive and negative.

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

- Providing environmentally sound electricity by identifying the optimal carbon sequestration techniques for a region, this project will begin to develop the information that is needed to devise cost-effective strategies to mitigate CO<sub>2</sub> releases from power plants.

**Proposed Outcomes:**

1. Provide researchers and policy makers with sound assessments on which to base research and policy decisions related to carbon sequestration options for agricultural soils. Many companies are already investigating promising carbon mitigation opportunities in the event that mitigation of this nature is required by future regulations, as well as to be able to participate in voluntary carbon-reduction programs and carbon-trading markets. This work will support those efforts.
2. Help identify the associated benefits and costs of carbon sequestration. Many carbon sequestration strategies have collateral environmental benefits, such as improved habitat, soil, and water quality decreased water and pesticide use and more sustainable land use and food production.

**Project Status:**

PIER released the scoping study in October 2004. The Kearney Foundation used the scoping study to develop a request for proposals to select a research team for this work. Kearney, the California Department of Food and Agriculture, and PIER selected researchers from UC Davis. The final report on the results of this work will be available by the spring of 2006.

## Assessment of Potential Health and Ecological Risks Associated with CO<sub>2</sub> Capture, Transport and Sequestration

**Contract #:** 500-01-025 **Work Authorization #:** E2I-WA-009

**Contractor:** Electricity Innovation Institute

**Project Amount:** \$25,000

**Contractor Project Manager:** Dick Rhudy (650) 855-2421

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### Project Description:

Carbon dioxide (CO<sub>2</sub>) capture, transport, and sequestration (CT&S) technologies could play a critical role in determining the future of coal-based electricity generation in a carbon-constrained world. Although a number of organizations are currently engaged in activities aimed at the creation of cost-effective CT&S technologies, little effort has been focused on possible health or ecological effects associated with large-scale deployment of CO<sub>2</sub> CT&S facilities (U.S. Department of Energy, Office of Science and Office of Fossil Energy, 1999, *Carbon Sequestration Research and Development*, and International Energy Agency, 2002. *Update on the CO<sub>2</sub> Capture Project*. Greenhouse Issues, No. 59. March 2002). Nonetheless, concern over the potential for health and ecological risks has begun to surface in the scientific and public policy communities.

In response to this need, EPRI will conduct an independent assessment of the potential health and ecological risks associated with CO<sub>2</sub> capture, transport, and sequestration. This will be accomplished through application of a four-step risk assessment paradigm. Hazard identification and dose-response assessments for a wide variety of generic site types and processes will be completed in the first phase of the project. Site-specific exposure assessments and risk characterization will be completed at one or more demonstration facilities in the second phase.

This project is a collaborative project being funded by the California Energy Commission and other organizations.

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

- Improving the environment and public health by conducting an independent assessment of the potential health and ecological risks associated with CO<sub>2</sub> capture, transport, and sequestration.

### Proposed Outcomes:

1. Provide data and analyses useful for siting, permitting, and operating CT&S facilities. Given the paucity of work conducted in this area to date, the data and resulting insights from this project likely will prove to be a crucial source of information for siting and permitting future CT&S facilities.
2. Create a comprehensive risk assessment framework for application in demonstration site(s) studies, as well as for use in siting and permitting future CO<sub>2</sub> CT&S facilities.
3. Catalogue data deficiencies and methodological issues that arise as the assessment is conducted. Identify research needed to reduce key uncertainties.

### Project Status:

The final report should be complete in the first quarter of 2005.

**Avian - Energy System Interaction Mitigation Program (UCSC)**

**Contract #:** 500-01-032 **Project #:** 1-9

**Contractor:** Regents - Santa Cruz

**Subcontractors:** United States Geological Survey

**Contract Amount:** \$3,000,433

**Match Amount:** \$273,600

**Contractor Project Manager:** Lynn Van Der Kamp (831) 459-1574

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Active

**Project Description:**

The purpose of this program is to conduct research for the development and application of methods and technologies for reducing and resolving negative impacts from avian electrocutions with utility poles and collisions with conductors and wind turbines. Electricity is transmitted throughout California via hundreds of thousands of miles of distribution and transmission lines. Avian electrocutions occur when a bird simultaneously touches two energized portions of the pole. Collisions with conductors are a fairly common event, particularly in high use bird areas and during inclement weather. Electrocutions and collisions with transmission systems result in bird deaths, and can result in power outages, high repair costs, and legal fines. These incidents are responsible for about 25% of outages in PG&E territory and 10% in SCE territory. Additionally, thousands of birds are killed annually in California from colliding with wind turbine blades. This issue is resulting in development moratoriums, law suits, and delays in meeting the renewable portfolio standard.

The Public Interest Energy Research Environmental Area (PIER-EA) selected the Santa Cruz Predatory Bird Research Group (SCPBRG) at the University of California at Santa Cruz to manage projects that develop and test new methods and technologies to reduce avian interactions with utility structures. A technical advisory committee (consisting of public agency, university, and industry members) is advising and directing the research and helping to ensure its applicability.

The goal of this work is to reduce avian fatalities and electrical outages caused by avian electrocution and collisions with power structures. UC Santa Cruz Predatory Bird Research Group (SCPBRG) conducted solicitations for research in 2003 and 2004 that focused on the development of tools, technologies, and protocols to evaluate, mitigate, and reduce avian interactions with energy structures in California and to evaluate the effectiveness of those measures.

Specifically, the researchers selected by the SCPBRG will: (1) conduct research and development in areas that are not adequately addressed by the competitive and regulated markets, and that will advance pertinent science or technology in this area, (2) identify, evaluate, and work toward resolving the environmental effects of energy delivery and generation in California, (3) collect high-quality data using well-documented quality assurance and quality control procedures, (4) disseminate results by publishing technical articles in peer-reviewed publications, and (5) develop practical, cost-effective tools, standards, guidelines, and procedures that can be used to reduce the incidence of harmful avian interactions with energy structures.

Three PIER-EA roadmaps provided direction for this work: A Roadmap for PIER Research on Avian Collision with Power Lines in California, A Roadmap for PIER Research on Avian Power Line Electrocution in California, and A Roadmap for PIER Research on Avian Interactions with

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Wind Turbines in California. Those roadmaps identified four research categories for work in this area—risk assessment, risk reduction, compliance monitoring, and technology transfer.

To date, the CEC PIER-EA/SCPBRG Avian Transmission systems Mitigation Program has awarded nine research projects listed below:

<b>Project Title</b>	<b>Award</b>	<b>Match Funds</b>	<b>Start Date</b>	<b>End Date</b>
“Raptor Electrocutation on Power Lines: Problem Assessment, Mitigation, and Monitoring” with United States Geological Surveys	\$59,153		1/30/2004	3/30/2006
Revising and Updating “Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996” with Southern California Edison and Edison Electric Institute	\$38,800	\$28,000	1/08/2004	12/31/2005
“Monitoring Raptor Fatalities and Validating a Preliminary Model for Predicting Electrocutation on SCE and PG&E Distribution Facilities” with Southern California Edison and Pacific Gas and Electric	\$232,400	\$227,100	12/04/2003	12/31/2005
“Evaluating and Reducing Avian Collision at the Cosumnes River Preserve” with Marcus L. Yee	\$35,940		4/15/2003	12/31/2005
“Raptor Mortality Field Guide” with EDM International, Inc.	\$16,430		6/01/2003	7/01/2004
“Bird Electrocutation Mitigation Web Site and Product Encyclopedia” with EDM International, Inc.	\$85,113	\$18,500	6/01/2003	7/01/2005
“Corona Testing – Devices to Mitigate Bird Collisions” with EDM International, Inc.	\$29,995		4/01/2004	9/01/2004
“Development of a Cost Effective System to Monitor Wind Turbines for Bird and Bat Collisions- Phase I” with EDM International, Inc.	\$44,500		11/01/2004	12/30/2007
“Monitoring System for Studying Avian and Wildlife Interactions with Power and Communication Facilities” with EDM International, Inc, and EPRI	\$252,000	\$73,900	11/01/2004	12/30/2007

**This project supports the following PIER program objectives of:**

- Improving the energy cost/value of California’s electricity by reducing costs associated with avian-caused power outages and retrofitting transmission systems with bird-friendly designs.

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- Improving the environmental costs/risk of California's electricity by providing effective tools to reduce avian fatalities from interactions with energy systems.
- Improving the reliability and quality of California's electricity by reducing the number of power outages caused by avian interactions with transmission systems.
- Providing greater choices for California consumers by providing mitigation measures and siting options that result in fewer bird collisions with wind turbines thereby reducing opposition to wind development and lifting development moratoriums.

### **Proposed Outcomes:**

Preliminary results were presented in a workshop at the Raptor Research Foundation Annual North American Meeting in mid-November 2004. Development of individual project reports began in 2004. Two reports have been completed to date:

- Corona Testing Devices to Mitigate Bird Collisions (publication number: 500-04-086F. PIER Web Address: [www.energy.ca.gov/reports/CEC-500-2004-086F.PDF](http://www.energy.ca.gov/reports/CEC-500-2004-086F.PDF)).
- Guide to Raptor Remains – A photographic Guide for Identifying the Remains of Selected Species of California Raptors (web location: [www2.ucsc.edu/scpbrg/remains\\_guide.htm](http://www2.ucsc.edu/scpbrg/remains_guide.htm)).

Several other reports will be available in 2005. A final draft report on the entire program is expected June 2006. Several reports will also be submitted to peer-reviewed journals.

### **Project Status:**

Further solicitations and awards for other proposals are planned for 2005.

## California Environmental Sensing and Communications

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-002

**Contractor:** University of California, San Diego - Scripps Institute

**Project Amount:** \$147,000

**Contractor Project Manager:** Dan Cayan (858) 534-4507

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### Project Description:

The purpose of this project is to develop new environmental sensors that will be used to start collecting California meteorological and hydrological data at a high profile remote location in the State. In recent decades, streamflow records collected at relatively low elevations suggested that an alarming shift toward earlier snowmelt has been occurring in the Sierra Nevada, a possible impact of global warming. This trend can lead to increased danger of floods in the winter season, lower availability of water during the summer, and less reliable hydropower production. Unfortunately, due to the high cost and difficulty of data collection, there is a lack of data that are necessary to detect, understand, and evaluate the impacts of this trend.

To address these problems, this project will develop a relatively low-cost sensor/data logger/transmitter system. This system will be designed to measure key meteorological and hydrological parameters such as snow cover, precipitation levels, wind velocity, humidity, temperature, and solar radiation.

Once developed, the system will be deployed in Yosemite National Park. Subsequent projects will result in the installation of more monitoring systems in remote locations and/or high elevations, areas of the State that are poorly covered with existing monitoring technology.

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

- Improving the environmental and public health cost/risks of California's electricity by designing and constructing a low-cost meteorological/hydrological data logging/sensing hardware system that can be installed in remote locations.
- Improving the reliability, quality, and sufficiency of California's electricity by gathering the data that will allow, in the future, the evaluation and enhancing of regional climate and hydrologic models. These models will allow the State to better manage its energy and water resources.

### Proposed Outcomes:

1. Develop non-intrusive and less expensive remote monitoring systems to substantially increase the number of monitoring sites and monitoring parameters for measuring key regions of the State.
2. Install these monitors in Yosemite National Park.
3. Provide public access to the data using the California Climate Data Archive ([www.calclim.dri.edu/](http://www.calclim.dri.edu/)).
4. Minimize the economic and societal impacts of climate change to California.

### Project Status:

All the major research activities are over. Scripps is now preparing the draft final reports which will be available by the end of summer 2005.

## Cooling Tower Water Quality Parameters for Degraded Water

**Contract #:** 100-98-001 **Project #:** 41

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

**Project Amount:** \$140,000

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O’Hagan (916) 653-1651

**Status:** Active

### **Project Description:**

The purpose of this project is to conduct a literature review to reexamine cooling water quality standards in the context of current practices and to develop new water quality parameters that consider the most current information and treatment approaches.

Given the increasing demands on California’s limited water supplies, power plant operators are turning to degraded water sources for power plant cooling. *Degraded water sources* are water supplies that are not readily suitable for most other uses because they contain naturally occurring or human-induced pollutants. Such water sources include effluent from wastewater treatment plants, naturally occurring brackish groundwater, and surface and groundwater bodies contaminated by pesticides, solvents, and other pollutants. Although some types of degraded water supplies have been used for power plant cooling, the use of such sources raises unique concerns for power plant operators. Even when using the best quality water, cooling water chemistry must be closely monitored to avoid corrosion, scaling and biofouling – and the use of degraded water only heightens these concerns.

The recommended current cooling water quality criteria do not specifically address the use of degraded water supplies, the use of newer technologies such as high-efficiency “film-pack” fills, nor the tendency to increase the number of times that water is cycled through the cooling tower.

This work includes an assessment of cooling tower systems that use high-efficiency “film pack” fills in conjunction with the use of recycled or reclaimed waters at higher cycles of concentration. The final report will recommend techniques that power plant operators can use to maintain water quality while also optimizing cooling system operation and reducing harmful impacts to aquatic organisms.

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

- Providing environmentally sound electricity by bringing cooling water quality criteria up to date and ensuring that they address the use of degraded water supplies, newer cooling technologies, and greater cycling of water through cooling towers. Greater use of degraded water for power plant cooling can conserve California’s limited freshwater supplies for other, more appropriate uses.
- Providing reliable electricity by potentially decreasing incidences of corrosion or fouling in cooling systems, resulting in less frequent maintenance outages. By determining and recommending appropriate water quality parameters, power plant operators can reduce downtime and increase electricity production.

### **Proposed Outcome:**

1. Minimal environmental impact from power plant cooling water. Establishing up-to-date water quality parameters will help ensure that power plants minimize their environmental impact on associated water bodies.

**Actual Outcomes:**

1. The report developed a methodology to evaluate potential water sources for power plant cooling, providing an updated procedure to analyze source water chemistry on a more realistic basis. Tools such as pH/speciation relationships, ion association, adjusted solubility constants, etc. are provided to analyze the usability of degraded water (as well as potable water) for cooling systems.
2. A water quality calculator is provided to conduct site-specific evaluations of source waters being considered for cooling water at power plants. The calculator incorporates the methodologies developed for speciating and balancing source water chemistry and utilizes analytical tools such as pH/speciation relationships, ion association, adjusted solubility constants, etc. to quickly evaluate source candidates. Also, the calculator enables the user to easily assess the effects of cooling system pH and operating temperature. The calculator is provided as an Excel spreadsheet.

**Project Status:**

A final report, including the calculator will be published on the Energy Commission website in the first quarter 2005.

## Development of Indoor and Ambient Portable Air Monitors

**Contract #:** 500-01-031

**Contractor:** California Air Resources Board (CARB)

**Subcontractors:** University of Southern California : University of California, Berkeley

**Contract Amount:** \$500,000

**Match Amount:** \$500,000

**Contractor Project Manager:** Richard Vincent (916) 323-5774

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Active

### Project Description:

The purpose of this collaborative project is to develop and demonstrate one or more portable, inexpensive, real-time ambient air monitor(s) capable of characterizing ambient air quality for power plant siting, including distributed generation (DG) units and environmental justice (EJ) considerations. The California Energy Commission and the California Air Resources Board (CARB) are jointly participating in this effort.

Several studies have shown that minority and low-income communities overall are exposed to more environmental hazards and power plant emissions can constitute one aspect of exposure. Environmental justice is a matter that is addressed at both the federal and state levels, and these evaluations are a part of California's power plant licensing process. The monitors currently in use are too expensive to purchase, install, operate, and maintain to provide the desired air monitoring coverage for these applications. The project will develop a new, portable, easier-to-use and less-expensive monitor for this purpose.

This project will also develop at least one portable indoor air monitor that can be used to obtain better information on the impact of energy-related activities on indoor air quality (IAQ). Indoor air concentrations of many pollutants can be many times higher than outdoor levels. The ambient air monitor will focus on criteria pollutants whereas the indoor monitor may focus on toxins.

Researchers and regulators will be able to use portable ambient air monitors to monitor ambient air at the location of proposed power plants, which will improve confidence in monitored data quality and enhance Commission siting decisions. The reduction of both cost and footprint will improve opportunities for both site specific and general monitoring of pollutants as well as assessments of personal exposures. Indoor air monitors could improve public health by measuring levels of indoor air pollutants and identifying problem locations. On-site monitoring will enhance the ability of California's air districts to determine emissions in ambient and indoor air from distributed generation technologies.

Researchers have conducted a scoping study that identified priority pollutants that need to be monitored. The Energy Commission is particularly interested in measuring particulate matter up to 10 micrometers in size (PM<sub>10</sub>) and particulate matter up to 2.5 micrometers in size (PM<sub>2.5</sub>), ozone (O<sub>3</sub>), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), and volatile organic compounds (VOCs), because they are contained in (or result from) power plant emissions. Instruments and technologies suitable for ambient and indoor air monitoring were identified and evaluated including: existing monitoring instruments and technologies, instruments and technologies under development, instrument and technology gaps, and organizations with the expertise to bridge those gaps.

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

- Providing environmentally sound and safe electricity by enabling Energy Commission staff and others to conduct site-specific siting and EJ analyses in any location where the need arises and provide the analyses to the appropriate decision-makers.

**Proposed Outcomes:**

1. Produce an instrument capable of categorizing PM by size.
2. Produce an instrument capable of measuring total PM mass and indicate the source (e.g., diesel, tobacco, or woodsmoke).
3. Develop a low cost, portable, instrument for PM monitoring that will provide continuous monitoring of total PM mass.

**Project Status:**

Work has started under two contracts to develop low-cost portable instruments that will measure ultrafine, PM<sub>2.5</sub> and PM<sub>10</sub>. The first contract will produce an instrument capable of categorizing PM by size. The second will provide an instrument capable of measuring total PM mass as well as an indication of the source (e.g., diesel, tobacco, or woodsmoke). The engineering design phases have been completed and fabrication of components is well underway. A third contract for the development of a low cost, portable, instrument for PM monitoring has been developed and the kickoff meeting was held in August, 2004. This instrument will provide continuous monitoring of total PM mass.

## Ecological Impacts of Pulsed Flows from Hydroelectric Facilities

**Contract #:** 500-01-044

**Contractor:** University of California, Davis

**Contract Amount:** \$1,987,024

**Contractor Project Manager:** Douglas Conklin (530) 752-7601

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Active

### Project Description:

The purpose of this project is to develop a scientific framework for assessing possible short and long-term ecological impacts of pulsed flow releases on California stream systems regulated for hydropower production. The majority of the State's hydropower capacity is in facilities that use water impoundments, such as dams. These peaking facilities can discharge stored water to generate electricity almost instantaneously during peak demand periods. This flexibility is a crucial asset in the State's electricity system. The ability to dispatch electricity with little notice is a great asset to the reliability of California's electricity grid, however, the abrupt and abundant release of water from hydropower plants into the rivers and streams below them – a technique known as "pulsed flows" – affects the aquatic habitats and organisms that live in those water bodies.

How specific flows affect aquatic habitats and their inhabitants is a matter of considerable uncertainty. The lifecycles, habitat needs, and environmental control factors governing behavior are poorly understood for many aquatic species, which makes it difficult for hydro plant operators and regulators to balance flows in a way that protects the long-term viability of native and recreational fisheries while maximizing power production. Moreover, this uncertainty results in a failure to realize the full economic and recreation potential of stream resources, a failure to protect aquatic communities, or both.

PIER and the Center for Aquatic Biology and Aquaculture (CABA) at University of California, Davis (UCD) developed a technical advisory group consisting of agency, utility, and stakeholder representatives. This advisory group:

- Reviewed the quality and availability of scientific data on the ecological impacts of pulsed and manufactured flows on California stream habitats and biotic communities.
- Determined whether current sampling, analytical and mitigation methods are adequate to detect, predict and resolve potential effects of pulsed flows from load-following hydroelectric, recreational and sediment management releases on aquatic habitats and biotic communities.
- Examined the suitability of new/different sampling and analytical methods to detect and predict potential effects of recreational flow, and load-following hydroelectric releases on aquatic habitats and communities.
- Identified and prioritized research based upon these assessments that is needed to improve sampling, analysis, mitigation and monitoring of the ecological effects of pulsed and manufactured flows on freshwater habitats.
- Will evaluate research proposals and products awarded under the two requests for proposals issued under this project.
- Will assist in developing and disseminating results to other agencies, researchers, and industry.

CABA has prepared two requests for proposals under the direction of the advisory group.

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

- Providing environmentally sound and safe electricity. This work will help improve and maintain the health and safety of aquatic environments associated with hydro plants by helping operators and regulators prevent adverse effects on downstream aquatic life and habitats.
- Improving the reliability of California's electricity by better understanding the effects of water releases on downstream organisms and habitats. This work may improve the ability of many of California's hydroelectric facilities to respond to peak electricity demand thereby increasing electricity system reliability.
- Improving the energy cost and value of California's electricity by preventing lasting effects on the structure and function of aquatic ecosystems. This work will help maintain the value of aquatic habitats for both native and recreational fisheries.

**Proposed Outcome:**

1. Understand how pulsed and manufactured flows impact sensitive species and aquatic communities. This will allow stream managers and regulatory agencies to effectively tailor flows for maximum electricity, economic, recreational and environmental benefits.

**Project Status:**

This project was approved in the fourth quarter, 2002. In late 2003, ten proposals were submitted in response to a request for proposals and five proposals were funded. Fourteen proposals were submitted in response to a second request for proposals which was issued in September 2004. Three projects submitted under this request for proposals are being funded. The project is expected to be completed by spring 2007.

**Effect of Transmission Line Corridors on the Demography of the Endangered Plant Kern Mallow & on Plant Species Composition in the Lokern Area**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** California State University, Stanislaus

**Project Amount:** \$62,703

**Contractor Project Manager:** Ellen Cypher (661) 398-2201

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

**Project Description:**

PIER Environmental Area (PIER-EA) funded work by the California State University Stanislaus to help ensure that current and future transmission lines in the Lokern area, in Kern County, California, do not contribute to the decline of the federally listed endangered plant Kern mallow, or to the degradation of habitat for rare and endangered animals. Designated as an “area of critical concern,” this land is home to a number of state and/or federally listed species.

California’s electricity transmission lines connect generating plants to substations. When new or increased electricity demand requires transmission lines to cross sensitive habitat, those responsible for siting new transmission lines need information on the potential impacts of those lines on any of the hundreds of California’s threatened or endangered species.

This need is especially urgent now, because the State needs to expand its transmission lines. A recent study of transmission research and development in California concluded that grid congestion, reliability problems, and higher costs have arisen because the California transmission system has not kept pace with demand over past two decades. Moreover, the new renewable energy units that will be brought on line in response to the State’s Renewable Portfolio Standard will need new transmission lines to tie them to the electricity grid.

The project: (1) determined whether Kern mallow plants in transmission line corridors had the same survival and reproductive rates as those outside of the corridors, (2) determined whether transmission line corridors were contributing to the dominance of non-native plants in the Lokern area, (3) determined whether the Kern mallow population was stable or declining overall, and (4) provided preliminary recommendations for the management of transmission line corridors in the Lokern area.

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

- Providing environmentally sound electricity by identifying the environmental and habitat impacts of new transmission lines and the management of existing transmission lines. This work will help protect rare and endangered species in the Lokern area.

**Proposed Outcomes:**

1. Planners and decision makers will be able to use the results of this study if transmission infrastructure expansion becomes necessary in this area, while they minimize impacts to resident species.
2. The methodology and the recommendations may also be helpful in other parts of California where transmission lines and roads conflict with endangered species.

**Project Status:**

The Final Report will be completed in 2005 and results will be summarized in the 2005 Annual Report.

## El Dorado Spray Enhancement

**Contract #:** 500-02-014 **Work Authorization #:** E2I-WA-103

**Contractor:** Electricity Innovation Institute

**Subcontractors:** John Maulbetsch : Michael DiFillipo

**Project Amount:** \$715,776

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O’Hagan (916) 653-1651

**Status:** Active

### **Project Description:**

A recently completed California Energy Commission (CEC)/Electrical Power Research Institute (EPRI) demonstration on the spray enhancement of dry cooling technology established the promise of inlet air spray cooling as an enhancement technique for the performance of air-cooled condensers (ACC) at power plants. It remains to test the approach under full-scale operating conditions in order to confirm performance predictions, to develop a generalized design approach, to identify and resolve remaining practical operating issues, and to establish supportable capital and operating costs for a complete system.

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

- Improving the Energy Cost/Value of California’s Electricity by increasing the output of power generators using dry cooling systems, enabling them to deliver more electricity to the grid and increase the reliability of California’s electrical system. Cost-effective and technologically feasible dry cooling systems can also enable power plants to be built closer to the end-users in areas where water is in short supply.
- Improving the Environmental and Public Health Cost/Risk of California’s Electricity by reducing fresh water use considerably, leaving more fresh water in the natural environment or for delivery to customers.
- Improving the Safety of California’s Electricity by helping to alleviate potential public health and safety issues by reducing potential surface and groundwater contamination, salt deposition from cooling tower drift, Legionnaires’ Disease, vapor emissions from volatile organic chemicals, and trihalomethane exposure.

### **Proposed Outcomes:**

1. Test the ACC spray enhancement system under full-scale operating conditions in order to confirm performance predictions.
2. Develop a generalized design approach.
3. Identify and resolve remaining practical operating issues.
4. Establish supportable capital and operating costs for a complete system.

### **Project Status:**

A host site for demonstration has been secured. The demonstration is planned for summer 2005.

## Energy-Related Indoor Environmental Quality Research

**Contract #:** 500-02-023

**Contractor:** California Air Resources Board (CARB)

**Subcontractors:** University of California, Berkeley

**Contract Amount:** \$2,500,000

**Match Amount:** \$500,000

**Contractor Project Manager:** Peggy Jenkins (916) 323-1504

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Active

### Project Description:

The purpose of this project is to quantify the effects of building characteristics, energy use and practices, and sources of indoor pollution on indoor environmental quality (IEQ) in California. Research goals are to: (1) obtain information that can be used to better understand the sources of indoor air pollution and identify how emissions from those sources relate to energy consumption, (2) quantify the relationship between IEQ and energy use, and (3) provide guidance for improving IEQ while reducing energy consumption.

The California Energy Commission establishes energy efficiency standards for buildings in the State, and these standards promote efficient energy use by mandating requirements for building features such as heating, ventilation, air-conditioning (HVAC), appliances, and lighting.

However, because compliance with these standards affects the use of building materials and air flows in a building, it is necessary to ensure that these requirements maintain or improve indoor air quality as they increase building efficiency.

The quality of indoor air has a significant effect on occupant health. Pollutant levels inside buildings may be two to five times higher than those outside, and people may be 1000 times more likely to be exposed to pollutants indoors than outside. This exposure results in increased asthma and other respiratory problems, and increased cancer risk. In fact, the California Air Resources Board (ARB) estimates that 200 cancer cases arise each year in California as a result of indoor chemical pollutants.

The ARB has conducted IEQ research for more than a decade, and results from ARB-sponsored research has been used widely by state, federal, and local entities, and by industry. For this project, PIER Environmental Area (PIER-EA) is working with the ARB to support the following studies:

- Ventilation Practices and Housing Characteristics in New California Homes. Researchers will conduct a mail survey of a large sample of owner-occupants of new California homes to obtain information on building characteristics, ventilation practices and equipment, indoor pollutant sources, occupant activities, and occupant comfort and satisfaction. They will then analyze the relationships among ventilation practices, perceived indoor air quality, and house and household characteristics, and identify barriers to the use of natural ventilation (windows and doors) and mechanical ventilation. The study results will also be used to design a field study to measure indoor air quality and ventilation characteristics in new homes. The survey and field study will provide information needed by the Commission to assess the impact of current energy efficiency standards and help determine the need for mechanical ventilators in new homes.

- Analyses of Building Characteristics and Indoor Environmental Quality in California Classrooms.

This project builds on the ARB California Portable Classrooms Study (PCS). Using data from the PCS, this project will characterize the distribution of energy and comfort-related characteristics of portable and traditional classrooms in a statewide, representative sample of kindergarten through twelfth grade (K-12) public classrooms from the PCS. It will also explore in detail the relationships among key building variables, such as building age and ventilation system type and condition, and IEQ measures in the PCS data set.

The Commission establishes building energy efficiency standards for California, including ventilation requirements intended to assure adequate indoor air quality and thermal comfort. The PCS data offer an opportunity for the Commission to gain insight on various energy efficiency measures, the impacts of those measures on IEQ and comfort, and the specific causes of and solutions to those impacts. In addition, ARB and the Commission are currently working with the Department of General Services (DGS) to revise State standards for leased portable classrooms, including standards for ventilation systems and lighting systems. These DGS standards also serve as a baseline for manufacturers of other portable classrooms sold in California, and therefore are widely utilized and can have a widespread effect on classroom design and performance, which in turn affects student and teacher performance.

- Characterize Indoor Source Emissions.

The goal of this project is to increase the body of knowledge regarding the emissions of office machines that currently enjoy a substantial market share in California, and to examine ways those emissions and occupants' exposures to them can be reduced. In this project, researchers will measure emissions from commonly used office equipment. This will provide a basis to improve IEQ by reducing emissions or promoting low emitting equipment without adversely impacting energy efficiency of buildings.

These research areas were identified in a national research plan on energy-related IEQ that was developed by a nationally recognized team of indoor air experts, under the direction of the PIER Buildings program and others. Research and development priorities identified in the national plan reflect the strong need to collect and analyze benchmark data on IEQ conditions and ventilation in small commercial buildings, schools, and residences.

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

- Providing environmentally sound and safe electricity products developing data that can be used by the Commission, other agencies, regulators and industry to develop energy-efficient and effective indoor environmental quality (IEQ) measures and technologies.
- Providing cost-effective energy use by reducing the level of indoor pollutants and improving the design and operation of ventilation technologies, which may reduce energy use and the cost of operating those systems.

**Proposed Outcome:**

1. Provide a better understanding of the relationship between indoor IEQ and energy use and provide guidance for achieving both improved indoor energy efficiency and improved IEQ. The results of this project will be used in developing building standards.

**Project Status:**

This project is on schedule. To better understand the ventilation practices and housing characteristics in new California homes, a survey has been developed and sent to owners of homes one to three years old. Analyses have begun on data collected during the portable classroom study. The methodology and subcontractor to characterize emissions from office equipment has been identified. The final report on the results of this work will be available by spring 2008.

## **Integrated Forecast and Reservoir Management Demonstration for Northern California**

**Contract #:** 500-02-008

**Contractor:** Hydrologic Research Center (HRC)

**Subcontractors:** Georgia Water Resources Institute : Dr. Aris Georgakakos

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

**Match Amount:** \$755,795

**Contractor Project Manager:** Konstantine Georgakakos (858) 794-2726

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Active

### **Project Description:**

The purpose of this project is to demonstrate an approach to improving runoff forecasting and reservoir management in Northern California with the aim of maximizing, with existing infrastructure, hydropower production and water supply. California's in-state hydropower facilities constitute 27 percent of its generation capacity and supply the State with an average of 15 percent of its electricity each year. However, the amount of electricity that a hydro plant can generate in any given year is based on California's variable climate (which determines the amount and timing of rainfall and snowpack runoff) and competing municipal, agricultural, and environmental needs.

Although the amount of rainfall and snowpack can differ greatly from year to year, both electricity and water demand continues to climb. To generate as much power as possible from hydroelectric facilities, managers must be able to estimate the most efficient use of water on a daily, weekly, monthly, and yearly basis. In this three-year effort, PIER Environmental Area (PIER-EA) and the Hydrologic Research Center will implement an ensemble of a forecasting system that will provide reservoir managers daily, weekly, and monthly probability estimates for runoff, based on historic and simulated data.

To implement these runoff forecasts, the project will develop a decision support system to assist reservoir managers to balance hydropower production and water supply needs with other needs such as flood control and instream flows. This Integrated Forecast and Reservoir Management Demonstration (INFORM) will be conducted at the Folsom, Oroville, Shasta, and Trinity reservoirs. Based on data collected from these sites, researchers will quantify improved water management efficiencies and document forecast and management methodologies and models.

In the first phase of the project, researchers will simulate runoff probabilities for the upstream watersheds for the four reservoirs. This will be achieved through the use of historic data and simulations of runoff conditions with global climate models. A major effort of this phase of the project will involve the testing and validating of methods to downscale information from global climate models to a scale suitable for the hydrologic forecast models.

The project will also develop an interlinked Sacramento River Decision Support System (SRDSS) of models for the four reservoirs, including an integration of climate and an ensemble of hydrologic upstream forecasts and long-range decision modeling for the entire Sacramento system. To facilitate the evaluation of impacts from reservoir site release decisions, researchers will assemble and formulate hydrologic models as needed for the downstream Sacramento River.

Once the SRDSS has been used and validated, researchers will develop and include a policy assessment model in the system. The model will quantify the system response for a specified

inflow sequence, streamflow forecasting scheme, and operational policy. At the completion of the forecast-decision-simulation process, the program will generate sequences of all relevant system performance measures, including reservoir levels, releases, energy generation, flood stages, instream flow conditions, and water supply deficits, if any. These sequences could be used to compare the benefits and consequences of various inflow scenarios, forecast-decision configurations, and operational policies.

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

- Providing environmentally sound electricity by improved runoff forecasting and reservoir management. This will provide for increased hydropower production and water supply without additional environmental damage. In addition, electricity produced by hydropower generation displaces the need for electricity that would otherwise most likely be generated by fossil-fuel generating plants.
- Improving the reliability of California's electricity by developing better water use forecasting that will enable hydropower plant managers to maintain or even increase hydropower production at California hydropower facilities. Using this fuel-free in-state source bolsters the State's energy reliability and independence. Hydropower can also be put online quickly, which can help alleviate shortages elsewhere.
- Providing affordable electricity by increasing the efficiency of hydropower plants. Hydroelectric generation is among the lowest-cost means of generating electricity, and this project will help California maintain its supply of this inexpensive, environmentally-clean source of electricity.

**Proposed Outcomes:**

1. Provide reservoir managers daily, weekly and monthly probability estimates for runoff, based on historic and simulated data.
2. Develop a decision support system to assist reservoir managers to balance hydropower production and water supply needs with other needs such as flood control and instream flows.
3. Develop an interlinked Sacramento River Decision Support System (SRDSS). The model will quantify the system response for a specified inflow sequence, streamflow forecasting scheme, and operational policy.

**Project Status:**

Initial efforts on this project began in the fourth quarter 2002 and are continuing. Updating of climatic model parameters is continuing as is downscaling protocols. Stand alone hydrologic models for the Trinity and Shasta Reservoir catchments are complete and are being tested. Model completion for the Folsom and Oroville Reservoirs are expected this year. Decision support models for Oroville and Folsom reservoirs have been developed and are currently being tested.

## Is Efficiency Enough? Towards a New Framework for Carbon Savings in the California Residential Sector

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** Lawrence Berkeley National Laboratory

**Project Amount:** \$75,000

**Contractor Project Manager:** Richard Diamond (510) 486-4459

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### Project Description:

The purpose of this project was to explore—through data analysis, modeling, a literature review, and case studies—the unintended consequences that may result from using energy efficiency (as conventionally defined) as the criterion for designing voluntary programs, incentives, and regulations intended to reduce energy consumption and carbon emissions.

Energy efficiency programs have reduced electricity demand and the carbon emissions that contribute to climate change however, energy efficiency activities do not specifically reduce carbon emissions, which continue to grow. Despite efficiency gains, energy-related carbon emissions nationwide were 23% higher in 2000 than in 1980. Such statistics suggest that current definitions of energy efficiency overlook savings potential by failing to adequately address *absolute levels* of energy use. Current approaches fail to incorporate two significant U.S. trends that increase total energy use: power needs from computers and other office equipment are predicted to rise more than 9% a year through 2025, and the average U.S. home size grew more than 25% from 1975 to 2000.

Researchers reviewed the current literature and knowledge on electricity consumption versus efficiency, focusing on policies that affect electricity use in California residences. They conducted case studies on housing, refrigerators, and air-conditioners. For each energy service, they obtained available secondary or modeled data on rated efficiency and rated (or measured) energy consumption across a variety of models. Next, they analyzed these data to determine the relationships between absolute consumption and rated efficiency.

Finally, the researchers outlined an alternative framework, focusing on reduced energy consumption and carbon emissions (as well as improved efficiency) and discussed how this framework could be applied to policy and to the design of market transformation and regulatory programs to promote reductions in residential electricity use in California.

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

- Providing environmentally sound electricity by producing modified metrics and a framework that addresses total absolute levels of energy use as well as efficiency. Using them, California will be able to better design programs to reduce both energy consumption and carbon emissions.

### Proposed Outcome:

1. Produce modified metrics and a framework that includes absolute energy consumption into a definition of energy efficiency.

**Actual Outcome:**

1. The project produced modified metrics and a framework that includes absolute energy consumption into a definition of energy efficiency. Decision makers will be able to use these enhanced tools to incorporate greenhouse gas emissions reductions into efficiency policy, and thereby increase the benefits from energy efficiency investments.

**Project Status:**

The Final Report will be completed in 2005 and results will be summarized in the 2005 Annual Report.

## Life-Cycle Energy Assessment of Alternative Water Supply Systems in California

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** University of California, Berkeley

**Project Amount:** \$71,380

**Contractor Project Manager:** Arpad Horvath (510) 642-7300

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### Project Description:

The purpose of this project was to conduct life-cycle energy assessments of potential alternative water sources in California, including importation, wastewater reclamation (i.e., water recycling), and desalination.

As the availability of fresh water supplies in California dwindles, water planners search for alternative supplies that will meet the State's needs, such as new sources of imported water from other states, wastewater reclamation (i.e., recycled water), and desalinization. However, all of these options can require high amounts of electricity to process and/or deliver water. Already, water and wastewater utilities spend more than \$500 million a year on energy in California, so it is important to identify the least-cost alternatives.

A life-cycle assessment (LCA) of each option can determine both the energy used for each of these alternatives and the accompanying air emissions attributable to providing energy for each process. An LCA is a systematic, quantitative approach to evaluating the energy and environmental impacts of a product or process from cradle to grave. The assessment includes design, planning, material extraction and production, manufacturing or construction, use, maintenance, and end-of-life fate of the product (reuse, recycling, incineration, or landfill). California-specific LCAs of water and wastewater systems have not yet been conducted.

Through LCAs, researchers evaluated these sources in urban areas, and:

- 1) Compared the economic implications, energy requirements, and air emissions attributable to energy consumption.
- 2) Evaluated the relative energy consumption and related air emissions of the different phases of the water supply system.
- 3) Evaluated the economic, environmental, and energy implications of separate distribution systems for potable and non-potable water.
- 4) Conducted a sensitivity analysis to determine parameters and processes in the water supply system that contributes most to energy use and related air emissions.
- 5) Recommended strategies to reduce energy and related environmental impacts of future water sources.

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

- Providing environmentally sound electricity by quantifying energy use and associated emissions for water supply alternatives. This will enable water planners and air regulators to better evaluate those options and minimize energy requirements and emissions. By helping water managers find viable alternatives, this work will help minimize the demand for freshwater supplies.
- Modifying electricity applications to help solve environmental problems. This project identified the most energy- and pollution-intensive processes in the water supply life cycle, helping to target future research in areas where improvements can be made most

readily. Other State agencies will also be able to use the methodology to analyze water and wastewater planning decisions.

**Proposed Outcomes:**

1. Compare the economic implications, energy requirements, and air emissions attributable to energy consumption.
2. Evaluate the relative energy consumption and air emissions of different phases of the water supply system—as well as of the economic, environmental, and energy implications of separate distribution systems for potable and non-potable water.
3. Conduct a sensitivity analysis that identifies the parameters and processes in the water supply system that contributes most to energy use and air emissions.
4. Recommend strategies to reduce energy and related environmental impacts of alternative water sources.

**Actual Outcomes:**

1. Compared the economic implications, energy requirements, and air emissions attributable to energy consumption.
2. Evaluated the relative energy consumption and air emissions of different phases of the water supply system—as well as of the economic, environmental, and energy implications of separate distribution systems for potable and non-potable water.
3. Conducted a sensitivity analysis that identifies the parameters and processes in the water supply system that contributes most to energy use and air emissions.
4. Recommended strategies to reduce energy and related environmental impacts of alternative water sources.

These results will provide California planners and decision makers with the economic and environmental information that they need to select the most appropriate water supply options for various applications.

**Project Status:**

The Final Report will be completed in 2005.

## Natural Gas Air Quality Issues

**Contract #:** 500-00-022 **Project #:** 1

**Contractor:** Gas Technology Institute

**Subcontractors:** GE Energy and Environmental Research Corporation

**Project Amount:** \$40,000

**Match Amount:** \$8,700,000

**Contractor Project Manager:** Paul Drayton (847) 768-0694

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Active

### Project Description:

The purpose of this project is to advance the understanding of particulate matter (PM) emissions from typical combustion sources. It is necessary to characterize source specific emissions to understand source contributions and to develop emission inventories. Proper characterization helps ensure that regulatory initiatives to address impacts from fine/ultrafine particulate emissions are based on inherently sound data resulting in equitable regulations that properly address public health concerns.

The overall project includes the following objectives:

- Develop improved dilution sampling technology and test methods for PM<sub>2.5</sub> (particulate matter smaller than 2.5 micrometers in diameter) mass emissions and speciation measurements, and compare results obtained with dilution and traditional stationary source sampling methods.
- Develop emission factors and speciation profiles for emissions of fine particulate matter, especially organic aerosols, for use in source-receptor and source apportionment analyses.
- Identify and characterize PM<sub>2.5</sub> precursor compound emissions that can be used in source-receptor and source apportionment analyses.

The goal of the Air Quality Project is to analyze ongoing regulatory developments and enable natural gas equipment (including gas-fired power generation and distributed generation) to meet and exceed the requirements of existing and anticipated air quality regulations.

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

- Reducing environmental, health, and safety impacts from energy production and use activities by developing the underlying science and technology to support the development of air quality regulations and enabling natural gas equipment to meet air quality regulations with least-cost technologies.

### Proposed Outcomes:

1. Topical Report: Dilution-Based Test Method for Speciated Measurement of Fine/Ultrafine Particulate in Combustion Exhaust and Comparison to Mass-Based Particulate Methods.
2. Topical Report: Speciated Fine/Ultrafine Particulate Measurements and Emission Factors from Industrial Combustion Sources.
3. Topical Report: Emission Characterization and Sources of Variability for PM Emissions from Gas Turbines.

**Actual Outcomes:**

1. Dilution-Based Test Method v. Mass-Based Methods - A dilution sampler and measurement protocol were developed to characterize the emission rates, chemical speciation and size of primary particles and reactive gases that lead to particle formation by atmospheric chemical reactions. Pilot-scale combustion tests were conducted to evaluate the effects of dilution sampling parameters (dilution ratio, residence time) for a variety of stack gas conditions produced by gas, oil, coal and doped gas combustion. The results were used to develop a new compact dilution sampler design. Preliminary validation tests comparing results from the compact dilution sampler and an existing benchmark design were performed in the field on a Diesel engine and a gas-fired power plant. The reconstructed PM<sub>2.5</sub> mass (sum of species adjusted for element oxides and organic carbon speciation) for gas-fired sources was typically greater than the measured PM<sub>2.5</sub> mass by 25 to as much as 200 percent or more in some cases. For the oil-fired boiler and the Diesel engine, the reconstructed and measured PM<sub>2.5</sub> mass are in good agreement (within approximately 10 percent). This implies a significant degree of positive bias in the PM<sub>2.5</sub> species measurements for the gas-fired sources.
  - a. Topical Report: Pilot-Scale Dilution Sampler Design and Validation Tests.
  
2. Speciated Fine/Ultrafine Particulate Measurements and Emission Factors from Industrial Combustion Sources - Dilution sampling measurement methods were applied to seven stationary sources to characterize emission rates and chemical speciation profiles for PM<sub>2.5</sub> and gaseous precursors. PM<sub>2.5</sub> (and precursor) emission factors and chemical speciation profiles were derived from the test results for gas-fired boilers and steam generators, gas-fired combined cycle and cogeneration power plants, gas-fired process heaters, No. 6 oil-fired boilers, and Diesel engines. For gas-fired sources, dilution sampling indicates PM<sub>2.5</sub> mass emissions are extremely low -- probably near ambient air PM<sub>2.5</sub> concentrations in many cases.
  - a. Topical Report: Fine Particulate Test Protocol.
  - b. Topical Report: Test Results for a Gas-Fired Process Heater (Site Alpha).
  - c. Topical Report: Test Results for a Dual-Fuel-Fired Commercial Boiler.
  - d. Topical Report: Test Results for a Gas-Fired Process Heater with Selective Catalytic NO<sub>x</sub> Reduction (Site Charlie).
  - e. Topical Report: Test Results for a Diesel Fuel-Fired Compression Ignition Reciprocating Engine with a Diesel Particulate Filter at Site Foxtrot.
  
3. Emission Characterization and Sources of Variability for PM Emissions from Gas Turbines – Particulate emission measurements were performed using an innovative dilution sampling protocol on a supplementary-fired natural gas combined cycle power plant (NGCC-SF) employing a heavy-duty gas turbine, heat recovery steam generator, steam turbine and post-combustion emission controls. Particulate mass emissions from this NGCC-SF (including post-combustion emission controls) are extremely low, qualitatively consistent with levels expected for gaseous fuel combustion based on published emission factors and other independent tests.
  - a. Topical Report: Test Results for a Combined Cycle Power Plant with Oxidation Catalyst and SCR at Site Echo.
  - b. Topical Report: Test Results for a Cogeneration Plant with Supplementary Firing, Oxidation Catalyst and SCR at Site Golf .
  - c. Test Results for a Combined Cycle Power Plant with Supplementary Firing, Oxidation Catalyst and SCR at Site Bravo.

4. Final Report - Development of Fine Particulate Emission Factors and Speciation Profiles for Oil- and Gas-Fired Combustion Systems.

**Project Status:**

The project is complete. Below is a summary of all the reports generated as a result of this project available on the web at:

- ⇒ [www.nysed.gov/programs/Environment/emepreports.asp](http://www.nysed.gov/programs/Environment/emepreports.asp)
1. Final Report - Development of Fine Particulate Emission Factors and Speciation Profiles for Oil- and Gas-Fired Combustion Systems.
  2. Update of Literature Review of Source Sampling and Analysis Methodologies for Characterizing Organic Aerosol and Fine Particulate Source Emission Profiles.
  3. Pilot-Scale Dilution Sampler Design and Validation Tests (Laboratory Study).
  4. Topical Reports/Technical Memorandum:
    - a. Technical Memorandum: Conceptual Model of Sources of Variability in Combustion Turbine PM10 Emissions Data.
    - b. Impact of Operating Parameters on Fine Particulate Emissions from Natural Gas-Fired Combined Cycle and Cogeneration Power Plants.
    - c. Fine Particulate Test Protocol.
  5. Site Test Reports:
    - a. Test Results for a Gas-Fired Process Heater (Site Alpha).
    - b. Test Results for a Combined Cycle Power Plant with Supplementary Firing, Oxidation Catalyst and SCR at Site Bravo.
    - c. Test Results for a Gas-Fired Process Heater with Selective Catalytic NO<sub>x</sub> Reduction (Site Charlie).
    - d. Test Results for a Dual-Fuel-Fired Commercial Boiler (Site Delta).
    - e. Test Results for a Combined Cycle Power Plant with Oxidation Catalyst and SCR at Site Echo.
    - f. Test Results for a Diesel Fuel-Fired Compression Ignition Reciprocating Engine with a Diesel Particulate Filter at Site Foxtrot.
    - g. Test Results for a Cogeneration Plant with Supplementary Firing, Oxidation Catalyst and SCR at Site Golf.

## Novel Approaches for the Reclaim & Reuse of Boiler Blow-Down Streams

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** University of Southern California

**Project Amount:** \$74,999

**Contractor Project Manager:** Theodore Tsotsis (213) 740-2069

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### Project Description:

The purpose of this project was to develop advanced concepts for reclaiming and reusing boiler blowdown water. The researchers: (1) surveyed and analyzed boiler blowdown effluents and discharges from selected electric utilities, and (2) performed preliminary reclaim/reuse studies with anionic clay materials, with a focus on arsenic and selenium, from boiler blowdown streams.

Power plant cooling systems can require up to five million gallons of water a day, so as competition for shrinking supplies grows, power plant managers are exploring the use of reclaimed water. Reclaiming and reusing water from other power plant processes is an obvious solution however, some operational, environmental, and health issues need to be addressed to ensure that such use is viable and safe. From an operational standpoint, it is necessary to understand reclaimed water's contribution to scaling on system equipment that can diminish cooling system effectiveness and increase operation and maintenance costs.

It is important to identify the levels of heavy metals in the reclaimed water and to develop methods for removing them. By doing so, power plants can protect both the health of workers and of the aquatic environments in which this water is discharged. In particular, research needs to resolve questions about the fate of trace amounts of mercury, selenium, and arsenic in reclaimed water. Most flue gas scrubber wastewater and boiler blowdown contain these metals, but conventional approaches are not capable of dealing economically with such streams. Questions of exposure and legal allowable limits of these metals in discharge water require that they be removed and disposed of safely.

The Gas Company of Southern California helped USC to identify, sample, and analyze power plant boiler blowdown effluents and discharges. Another collaborator, Media and Process Technology, Inc., supplied proprietary anionic clay materials that USC used as adsorbents in "surrogate" blowdown streams to test their effectiveness in removing arsenic and selenium from the water streams. Preliminary tests indicated that the spent adsorbent meets the toxicity characteristic leaching procedure (TCLP) test developed by the U.S. Environmental Protection Agency.

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

- Providing environmentally sound electricity. The adsorbent materials developed under this project should facilitate the reuse of boiler blowdown streams (and potentially, other power plant wastewater streams), thereby reducing the amount of fresh water needed for cooling system operation. In addition, it will help ensure that the trace metals in cooling water discharge are reduced to environmentally acceptable levels. The reuse of power plant water streams will reduce the need to find additional sources of conventional cooling water.

**Proposed Outcome:**

1. Produce an analysis of boiler blowdown effluents and discharges, studies of anionic clay materials and their usefulness in adsorbing arsenic and selenium from boiler blowdown streams, and advancements in the safe disposal of spent adsorbents.

**Actual Outcome:**

1. This project produced an analysis of boiler blowdown effluents and discharges, studies of anionic clay materials and their usefulness in adsorbing arsenic and selenium from boiler blowdown streams, and advancements in the safe disposal of spent adsorbents.

**Project Status:**

The Final Report will be completed in 2005 and results will be summarized in the 2005 Annual Report.

## Optimization of Product Lifecycles to Reduce GHG Emissions

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** Lawrence Berkeley National Laboratory

**Project Amount:** \$75,000

**Contractor Project Manager:** Ernst Worrell (510) 486-6794

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### Project Description:

The purpose of this project was to explore the potential role of product life cycle optimization to help reduce greenhouse gas (GHG) emissions in California.

In their quest to reduce energy usage, GHGs and other power plant emissions researchers have studied the energy use and accompanying emissions associated with many consumer products. Less studied, however, is the amount of energy used during the full life cycle of the product—that is, the energy used to produce it, operate it through its useful life, and ultimately dispose of it. Each segment of that life cycle offers opportunities for saving energy and further reducing emissions. One study of California’s energy efficiency potential estimated that implementation of a full spectrum of energy efficiency activities could reduce the State’s peak electricity demand by as much as 15,000 megawatts.

*Product life cycle optimization* is a process that can be used to help reap these energy and emissions reductions. In this process, researchers evaluate the production, use, and disposal of consumer products and use the resulting information to reduce the cradle-to-grave energy use and GHG emissions associated with that product.

For this project, researchers evaluated the product life cycle energy use and GHG emissions associated with the manufacture, use, and disposal of 50 major products manufactured in California. They also conducted case studies on personal computers and cement to assess the potential for GHG emission reductions from changes in these products’ three life cycle phases. In addition, researchers evaluated the policy framework for developing product life cycle optimization policies in California.

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

- Providing environmentally sound electricity by reducing the energy use over the life cycle of consumer products that will result in reduced electricity use, fuel use, GHG emissions, and criteria pollutants from power generation. This work will lead to improved air quality and lower statewide energy use. The total potential of these savings will depend on the type of products manufactured, the current efficiency within each life cycle of the product, and the costs and benefits of the efficiency opportunities available for the California-produced products.
- Providing reliable electricity by reducing overall energy use, which helps the State meet demand.
- Providing affordable electricity by lowering the demand for electricity in the State, which will reduce the investment necessary to license and develop additional power generation capacity in the State.

### Proposed Outcomes:

1. Identify which of the products studied could experience the most significant reductions in energy use and GHG emissions as a result of life cycle optimization.

2. Produce case studies on personal computers and cement.
3. Develop suggestions for developing product life cycle optimization policies in California.

**Actual Outcomes:**

1. Identified which of the products studied could experience the most significant reductions in energy use and GHG emissions as a result of life cycle optimization.
2. Produced case studies on personal computers and cement.
3. Developed suggestions for developing product life cycle optimization policies in California.

**Project Status:**

The Final Report will be completed in 2005.

## PIER Environmental Energy Research Program Technical Assistance

**Contract #:** 700-99-019

**Contractor:** Regents - Office of the President

**Contract Amount:** \$2,050,000

**Contractor Project Manager:** Carl Blumstein (510) 287-3320

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### Project Description:

The purpose of this Agreement is to obtain technical assistance to support the administration of the Public Interest Energy Research (PIER) Program in the Environmental Area. The University of California (UC) shall provide the services of faculty, staff, students and subcontractors to assist the Energy Commission in program planning, and program administration. The primary objective is the development of a PIER Environmental Area Research Development and Demonstration (RD&D) Plan. The Plan will provide a broad framework and justification for selected RD&D initiatives. The Plan will address ways of improving the scientific understanding of the adverse public health and environmental impacts attributable to the generation, transmission, and use of electricity, as well as ways of developing mitigation/enhancement strategies, tools, or technologies to address these adverse impacts.

To accomplish this work, UC assembled a core team. The core team developed the Plan, and provided oversight and planning for the overall PIER Environmental Area (PIER-EA). The core team developed a process for identification, development, evaluation, and refinement of RD&D initiatives for the PIER Environmental Area, including the development of comprehensive subject area research roadmaps.

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

- Improving the environment, public health, and safety of California's electricity by providing technical assistance to staff in the areas of air quality, land-use and habitat, aquatic resources, and global climate change.

### Proposed Outcomes:

1. Under the direction of Commission staff, identify key energy-related environmental issues that need to be addressed in each of the four PIER Environmental Subject Areas (air, land-use and habitat, global climate change, and aquatic resources).
2. Identify existing environmental research efforts relative to key issues of importance to California (status of present research, proposed work, relevance to California, opportunities for collaboration).
3. Identify major gaps in environmental research areas of importance to California.
4. Based on tasks listed above, prepare draft PIE-EA RD&D Plan.
5. Obtain, incorporate, and address stakeholder review comments on the draft Plan.
6. Finalize the PIER-EA Comprehensive Research Plan.
7. Create Planning Teams for the four subject areas (air, land-use and habitat, global climate change, and aquatic resources).
8. Develop comprehensive subject area research roadmaps.
9. Conduct workshop(s) to discuss roadmaps and projects to be developed.

### Actual Outcomes:

1. The PIER-EA RD&D Plan has been finalized and is available on the Commission web site. CEC staff obtained, incorporated, and addressed extensive stakeholder review

comments on the draft Plan. The Plan identifies the key energy-related environmental issues that need to be addressed in each of the four PIER Environmental Subject Areas (air, land-use and habitat, global climate change, and aquatic resources).

2. Planning teams have been created for the four subject areas and they have developed comprehensive research roadmaps. These roadmaps, in greater detail than the Plan, identify existing environmental research efforts relative to key issues of importance to California (status of present research, proposed work, relevance to California, opportunities for collaboration), as well as major gaps in environmental research areas of importance to California.

**Project Status:**

Each subject area has its own timeline for completion of draft roadmaps, informational workshops for comment and input on the draft roadmaps, finalization of the roadmaps, and ultimately competitive solicitations for projects to address the identified priority issues. Several workshops have been held and several roadmaps have been finalized. Additionally, some research programs have been designed to address the major roadmap issues. All work on this Interagency Agreement is nearing completion as the term of the project ends March 31st, 2005. This project is on schedule and within budget.

## Planning Atmospheric Carbon Monitoring in California

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** Lawrence Berkeley National Laboratory

**Project Amount:** \$75,000

**Contractor Project Manager:** Marc Fischer (510) 486-5539

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### **Project Description:**

The purpose of this project was to develop an effective atmospheric measurement strategy for comprehensive greenhouse gas (GHG) monitoring in California.

The California Energy Commission (CEC) has identified the ability to attribute sources of carbon dioxide (CO<sub>2</sub>) and other GHGs as a priority area for research, because future cost and production strategies for electricity production may be affected by economic and policy responses to global warming. It will be important for power producers and regulators to determine the GHG contribution of fossil fuel generators.

In the carbon cycle, carbon that is emitted by fossil fuel combustion is pulled out of the atmosphere and stored in “carbon sinks” such as vegetation, soil, and water bodies. Estimation of ecosystem carbon sources and sinks is a key problem for GHG accounting, because the mechanisms are not well understood. Also, it is difficult to estimate statewide carbon sources or sinks from changes in carbon stocks because it is expensive to study a sufficient number of areas to achieve a representative sampling over such a large region.

Currently, the CEC estimates GHG emissions using accounting data for fossil fuel emissions and a combination of inventory surveys and simple models for net ecosystem exchange (NEE), which is the net balance of ecosystem carbon fluxes into and out of the atmosphere. However, these carbon fluxes vary with climatic and land use and management changes, so the accuracy of these estimates is in question.

Researchers used modeling and analysis to determine optimized monitoring locations in California, and developed sampling protocols for gas species that will most contribute to the estimation of NEE with regional specificity and in the presence of GHGs from combustion.

The researchers conducted DOE-supported research focused on estimating NEE at regional scales in Oklahoma and Kansas, using a combination of tower-based flux measurements, tower and aircraft-based concentration measurements, and modeling of ecosystem-atmosphere modeling. This project built upon that work to help plan GHG concentration measurements for California.

### **The project supports the PIER Program objective of:**

- Providing environmentally sound electricity by establishing the foundation for a network of atmospheric monitoring sites and trace-gas sampling protocols that will enable researchers to more precisely identify the GHG contributions of fossil fuel combustion to global warming. The resulting tool will enable the quantification and verification of net GHG emissions, strategies for within-state carbon sequestration, and emissions trading. This project addresses state and national needs for quantification of terrestrial sources and sinks of carbon cycle gases.

**Proposed Outcome:**

1. Identify the optimal CO<sub>2</sub> monitoring locations in California, and develop sampling protocols for the gas species that most contribute to the estimation of net ecosystem exchange with regional specificity and in the presence of combustion-related GHGs.

**Project Status:**

The Final Report will be completed in 2005.

## **Preliminary Climatic Data Collection, Analyses, and Modeling**

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

**Contractor:** University of California, San Diego - Scripps Institute

**Subcontractors:** Western Regional Climate Center

**Project Amount:** \$1,200,000

**Contractor Project Manager:** Dan Cayan (858) 534-4507

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### **Project Description:**

The purpose of this project is to perform preliminary work on climate monitoring, analyses, and modeling for California.

In recent decades, stream-flow records suggest that an alarming change toward earlier snowmelt has been occurring in the Sierra Nevada, which may be an early indication of global warming or a result of natural fluctuations. If this trend continues, as suggested by recent research supported by PIER, there is an increased danger of floods in the winter, lower water availability during the summer, and less reliable hydropower production. Moreover, a preliminary PIER analysis indicates that climate change would increase energy demand by up to 20% beyond what is otherwise expected. The electricity system would be affected because of the expected increase in summer cooling demand.

To address these issues within a structured framework, PIER-EA developed a virtual research center: the California Climate Change Center. The Scripps Institution of Oceanography at the University of California at San Diego and the University of California at Berkeley are leading the Center's core research activities. Scripps is leading the work on climatic changes, and UC Berkeley is leading the research on economic impact and adaptation analyses. Additional research activities are conducted at other institutions selected under a competitive solicitation program. All projects are well-coordinated and joint projects by physical and social scientists are encouraged.

This summary addresses the Scripps work. The UC Berkeley work is outlined in a separate summary. Scripps' long-term core research activities are designed to answer the following questions:

- How is the California climate changing in relation to historical and pre-historical conditions? How much of this change can be attributed to natural variability?
- What are the expected signals of a changing climate in the State, and how should they be monitored?
- What are the potential changes of California climatic conditions, based on the increased concentration of greenhouse gases in the atmosphere?
- What is the estimated likelihood of the different climatic scenarios?
- How would the frequency and severity of extreme events change in the future?
- What is the potential from abrupt climate changes in the State, and how would the new potential climate look?

Scripps is addressing these questions by:

- 1) Continuing the installation of meteorological and hydrological monitors in key areas of the State.
- 2) Creating an extensive climatic and hydrological database system for the State available through the Internet.

- 3) Performing detailed analyses of climatic and hydrological trends.
- 4) Performing future model development work to create State climate scenarios.
- 5) Studying how climate in California is affected by large-scale oceanic and atmospheric circulations.

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

- Developing cost-effective approaches to evaluating and resolving the environmental effects of energy production, delivery, and use in California. The monitoring, data, analyses, modeling, and studies that will be performed by the Scripps portion of the California Climate Change Center can be used to address the impacts of climate change, which is partially caused by the carbon dioxide and other greenhouse gases emitted as part of electricity production.

**Proposed Outcomes:**

1. Analyze trends, collect important meteorological and hydrological variables in key sites in the State, and improve modeling approaches. There is an urgent need to better understand potential changes in climate in the State. Some regional climate models suggest that the State will receive less precipitation while others estimate an enormous increase in precipitation, making it very difficult to develop adaptation strategies under such a wide range of possibilities. This work begins to address this issue. Researchers, power plant operators, and policy makers will be able to use the monitoring, data, analyses, modeling, and studies to better understand the impacts of climate change on California, and how to mitigate, eliminate, and adapt to those impacts. As a result, the State will be able to better maintain a healthy population, environment, and economy.
2. Publish research reports.

**Project Status:**

This project started on January 17, 2003. Scripps has delivered several PIER reports and additional reports are expected in the near future.

This is a list of some of the reports already delivered:

- Fifty-Two Years of "Pineapple-Express" Storms Across the West Coast of North America. Publication Number: CEC-500-2005-004. Publication Date: December 2004.  
⇒ [www.energy.ca.gov/pier/final\\_project\\_reports/CEC-500-2005-004.html](http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-004.html)
- From Climate Change Spaghetti to Climate Change Distribution – Consultant Discussion Paper. Publication Number: 500-04-028. Publication Date: April 2004.  
⇒ [www.energy.ca.gov/global\\_climate\\_change/documents/](http://www.energy.ca.gov/global_climate_change/documents/)
- Parallel Implementation of the Regional Spectral Atmospheric Model. Publication Number: CEC-500-2005-014. Publication Date: February 2005.  
⇒ [www.energy.ca.gov/pier/final\\_project\\_reports/CEC-500-2005-014.html](http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-014.html)
- Predictive Relationship Between Pacific SST and Summer California Air Surface Temperature. Publication Number: CEC-500-2005-015. Publication Date: February 2005.  
⇒ [www.energy.ca.gov/pier/final\\_project\\_reports/CEC-500-2005-015.html](http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-015.html)
- Recent Advances in Regional Climate System Modeling and Climate Change Analyses of Extreme Heat. Publication Number: CEC-500-2005-016. Publication Date: February 2005.  
⇒ [www.energy.ca.gov/pier/final\\_project\\_reports/CEC-500-2005-016.html](http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-016.html)

## **Preliminary Economic Analyses of Climate Change Impacts and Adaptation, and GHG Mitigation**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-006

**Contractor:** University of California, Berkeley

**Project Amount:** \$1,100,000

**Contractor Project Manager:** W. Michael Hanemann (510) 642-2670

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Active

### **Project Description:**

The purpose of this project is to perform preliminary work on economic analyses of climate change impacts.

In recent decades, stream-flow records suggest that an alarming change toward earlier snowmelt has been occurring in the Sierra Nevada, which may be an early indication of global warming or a result of natural fluctuations. If this trend continues, as suggested by recent research supported by PIER, there is an increased danger of floods in the winter, lower water availability during the summer, and less reliable hydropower production. Energy demand will also be affected. A preliminary PIER analysis indicates that energy demand would increase by up to 20% beyond what is otherwise expected. The electricity system would be affected because of the expected increase in summer cooling demand.

To address these issues within a structured framework, PIER Environmental Area (PIER-EA) has developed a virtual research center: the California Climate Change Center. The University of California at Berkeley and the Scripps Institution of Oceanography at the University of California at San Diego are leading the Center's core research activities. UC Berkeley is leading the research on economic impact and adaptation analyses, and Scripps is leading the work on climatic changes. Additional research activities are conducted at other institutions selected under a competitive solicitation program. All projects are well-coordinated and joint projects by physical and social scientists are encouraged.

This summary addresses the UC Berkeley work. The Scripps work is outlined in a separate project summary. UC Berkeley's long-term core research activities are designed to answer the following questions:

- How will the impacts of climate change and measures to abate greenhouse gases (GHGs) affect the California economy in the coming decades?
- What are the key economic risks for California from climate change, and what are the particular risks from abrupt and/or extreme climate change?
- How will climate change affect the State's integrated water/agricultural system, and what will be the costs and benefits of policies to address potential impacts on this system?
- What are the costs and benefits of both price and non-price-based policies designed to increase energy efficiency in the California economy?
- How will energy-saving technological change affect the costs of carbon-abatement policies in California?
- How should California design regional markets for emissions trading?
- How should GHG-abatement and air quality policies be integrated?
- What are the costs of abating non-CO<sub>2</sub> GHGs?

UC Berkeley will begin to address these questions by:

- 1) Enhancing and applying a computable general equilibrium model of the California economy to estimate economic impacts of climate change on the State and measures to abate GHGs.
- 2) Conducting research to gauge how technological change may affect these impacts.
- 3) Analyzing underlying determinants of energy demand and their implications for the State's response to climate change.
- 4) Studying detailed economic aspects of the interrelations among potential climate change, California's engineered water infrastructure and water use for agriculture, hydroelectric generation, and household use.

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

- Developing cost-effective, approaches to evaluating and resolving environmentally the effects of energy production, delivery, and use in California. The modeling, data, analyses, and studies that will be performed by the UC Berkeley portion of the California Climate Change Center can be used to address the economic impacts of climate change.

**Proposed Outcome:**

1. Address the issues identified in the *PIER-EA Climate Change Research, Development, and Demonstration Plan* by collecting economic data and merging them with meteorological and hydrological data, analyzing the new data sets, and developing new macro-economic model for the State. There is an urgent need to better understand economic impacts of potential changes in California's climate, as well as how the State can plan for possible GHG-abatement policies, while ensuring continued economic growth and vitality.

**Project Status:**

This project started on April 4, 2003. A prototype version of the computable general equilibrium model is now available and several analyses are under way. PIER will release several reports reporting preliminary results in all the aspects of this work by May 2005.

## **Quantifying the Potential Air Quality Impacts from Electric Demand Embedded in Water Management Choices**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** The Pacific Institute

**Project Amount:** \$74,743

**Contractor Project Manager:** Gary Wolff (510) 251-1600

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### **Project Description:**

The purpose of this project was to develop a general methodology for quantifying the air pollutant emissions that result from electricity that is generated for various forms of water management.

To meet the growing demand for water in California, water managers must choose from various water sources and technologies to acquire, treat, and transport fresh water and then treat, recycle, or dispose of the resulting wastewater. Each water supply, treatment, and recycle/disposal option has significant electric consumption and air pollution impacts, and detailed information is needed to help managers determine the environmental implications of their choices.

For this project, researchers conducted a literature search and interviews with experts and developed two spreadsheet models of electricity consumption impacts of water management decisions—one urban and one rural. The Pacific Institute had worked with the Natural Resources Defense Council on a case study of the energy embedded in water supply/use/disposal pathways in a Southern California urban setting, and another case study of water embedded in agricultural water-use choices in a Central California setting. This work extended that project to include air emissions impacts from water management decisions.

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

- Providing environmentally sound electricity by making available a methodology that any water manager or water policy analyst in California will be able to use. Its use will result in more informed environmental decisions and policy making regarding the use of energy for water management options. This work also lays the foundation for large-scale research to make the analysis more location- and context-specific.

### **Proposed Outcome:**

1. Produce a general methodology for quantifying water-production-related air pollutant emissions, and urban and rural spreadsheet models of electricity consumption impacts of water management decisions.

### **Actual Outcome:**

1. This project produced a general methodology for quantifying water-production-related air pollutant emissions, and urban and rural spreadsheet models of electricity consumption impacts of water management decisions. The methodology, with full documentation and several case studies to illustrate the method is publicly available, so that others can analyze their own particular water management choices.

### **Project Status:**

The Final Report will be completed in 2005.

**Research on Estimating the Environmental Benefits of Restoration to Mitigate or Avoid Environmental Impacts Caused by California Power Plant Cooling Water Intake Structures**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** Stratus Consulting

**Project Amount:** \$71,319

**Contractor Project Manager:** Elizabeth Strange (303) 381-8000

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

**Project Description:**

The purpose of this project was to identify the key factors and methods necessary to develop reliable, quantitative estimates of the benefits of restoration efforts that mitigate or avoid the impacts of California power plant cooling water intake structures (CWIS) on fish and shellfish.

Millions of gallons of water can pass through a cooling water intake each day and aquatic life that are caught against or pulled into these structures can be injured or killed. During power plant licensing, the California Energy Commission often recommends structural or operational modifications (such as environmental restoration) that will mitigate or avoid such harmful impacts. However, there is no existing, standard method that can provide a reliable, quantitative estimate of the environmental benefits from specific restoration actions. As a result, the effectiveness and costs of environmental restoration are often called into question, and it is sometimes difficult for power companies, regulators, and other decision makers to identify and choose the amount (and subsequent cost) of restoration that is appropriate to mitigate or avoid the environmental losses for a particular situation.

Researchers identified data gaps that impede the development of reliable restoration type, amount, and cost estimates. They also identified field studies and monitoring programs that could fill those gaps. This information will support the development of regional restoration plans that can mitigate the environmental impacts of CWIS.

The research was conducted within the framework of the habitat-based replacement cost (HRC) method recently developed by the U.S. Environmental Protection Agency (EPA) to evaluate the impacts of CWIS on fish and shellfish in the Great Lakes and along the East Coast. The HRC approach estimates the types, amount, and cost of restoration actions that will increase production of biota to offset losses. The method is based on the resource replacement approach, and replacement is achieved through habitat restoration as opposed to conventional replacement techniques such as fish stocking. The HRC framework has been used by the EPA as part of their ongoing rulemaking process for CWIS under the Clean Water Act §316(b).

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

- Providing environmentally sound electricity by developing a strong scientific basis for selecting and scaling environmental restoration activities. This work will help operators, regulators, and decision makers identify and implement the most appropriate activities for offsetting the impacts of power plant CWIS. It will also serve as a blueprint that can be used to facilitate the development of methods that reliably quantify the environmental benefits of specific restoration activities, such as thermal discharge impacts on fish, aquatic or terrestrial habitat loss or degradation, or bird kills from wind turbines or transmission equipment.

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- Providing affordable electricity by developing a reliable method for identifying effective, economical environmental restoration solutions that could reduce mitigation costs, and subsequently, the costs for producing electricity.

### **Proposed Outcome:**

1. Develop a reliable, common methodology for identifying and quantifying effective environmental restoration solutions for each particular power plant situation.

### **Project Status:**

The Final Report will be completed in 2005.

## Short Range Dispersion Study

**Contract #:** 500-01-038

**Contractor:** California Air Resources Board (CARB)

**Subcontractors:** University of California, Riverside

**Contract Amount:** \$436,516

**Match Amount:** \$100,000

**Contractor Project Manager:** Tony Servin (916) 323-5122

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Active

### Project Description:

The purpose of this project is to improve air dispersion modeling so that elevated and ground-level urban power plant emissions can be modeled accurately over short distances to support environmental justice (EJ) evaluations and to account for the increased use of distributed generation (DG) technologies in California.

In 2002, the California Energy Commission and the California Air Resources Board (CARB) co-sponsored a workshop to evaluate the performance of existing, short-range dispersion models. Experts on short-range dispersion modeling from state and federal agencies, university and private research organizations, and private companies identified the limitations of these models and proposed research that would enable modelers to conduct more accurate and reliable short-range modeling.

This project addresses concerns expressed at the workshop, and builds upon work by the CARB and the University of California at Riverside (UCR) that is developing an algorithm to estimate the impact of near ground-level urban emissions sources at distances of tens of meters to a few kilometers from the source. The algorithm will be designed for incorporation into models such as AERMOD (a commonly used dispersion model), to improve the accuracy of dispersion modeling in urban areas. The project is also developing a model evaluation database from tracer experiments that have been conducted in several urban areas.

This project will:

- Develop a dispersion algorithm for ground-level (e.g., from distributed generation units) and elevated sources (e.g., from power plant stacks) in urban areas. This algorithm will account for changes in dispersion patterns caused by the urban environment and the land/sea locations in which many power plants in California are placed. It will also account for how ground level and elevated releases tend to disperse during different times of the day, particularly in urban areas.
- Conduct tracer gas studies with sulfur hexafluoride (SF<sub>6</sub>), including capturing and analyzing SF<sub>6</sub> concentrations downwind of a ground level and an elevated release.
- Evaluate the dispersion algorithm with the tracer field data.
- Use tracer data to evaluate a proposed dispersion model that may be able to better model inhomogeneous power plant plumes (that is, emissions in non-uniform, more turbulent air).
- Evaluate the performance of the ISCST3, AERMOD, and CALPUFF microscale models—as well as a Lagrangian particle dispersion model being developed at UC Riverside that will provide concentration estimates at very short distances (in scales of meters to tens of meters from a source).

Modeling results from this project will be shared with EPA’s Emission Modeling and Analysis Division, which is currently developing guidelines for air dispersion modeling of toxic pollutants in urban areas.

This work addresses issues identified in the PIEREA Distributed Generation and Environmental Justice roadmaps. It also addresses the Governor’s environmental justice directives, as well as the commitment of the Energy Commission and CARB to environmental justice issues.

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

- Providing environmentally sound and safe electricity by improving the accuracy of emissions dispersion models that will enable regulators and power producers to address health issues stemming from power plant emissions.
- Improving the reliability of California's electricity with increased use of distributed generation sources. This project will improve the ability of regulators and communities to evaluate where this equipment can be placed safely, which could speed its implementation and contribution to the State’s electricity system.

**Proposed Outcomes:**

1. Improve a modeler’s ability to determine impacts from power plant emissions in urban areas. Regulators can use these models for EJ determinations, to help determine whether emissions from a proposed power plant could present an undue risk to populations in adjacent areas.
2. Determine the localized air quality impacts of DG technologies.

**Project Status:**

The pilot tracer study was conducted using the stack at the Los Angeles Department of Water and Power peaking power plant in Wilmington. Data from those tests were analyzed and a technical report summarizing the findings was issued in April 2004. The results from the pilot study were used to develop the main field study work plan, which was completed in May of 2004. The main field study was conducted during the period August 26th to September 10th, 2004. The meteorological instruments and seventy-three integrated SF6 samplers were set up during the month of August. During the study period, weather conditions for the experiment were favorable during 8 days. A total of 3600 hourly average samples were collected and analyzed. A performance audit on the meteorological sensors and gas chromatograph sample analyzers was conducted and determined to be operating within the project goals. The technical report detailing the results of the main field study and model validation are currently underway and on-schedule. The final report on this study will be available in the spring of 2005.

## **Sustainable Urban Energy Planning Roadmapping**

**Contract #:** 500-02-029 **Project #:** 7

**Contractor:** Gas Technology Institute

**Subcontractors:** Alex Lantsberg

**Project Amount:** \$300,000

**Contractor Project Manager:** Doug Newman (847) 768-0680

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### **Project Description:**

The purpose of the Sustainable Urban Energy Planning (SUEP) Roadmapping Project is to assist the PIER Environmental Area (PIER-EA) Program in identifying appropriate areas for future research designed to support California local and regional governments' efforts to effectively engage in energy planning. The scope of this original project was for a larger national roadmapping effort with a focus on California. The scope was changed to just focus on California and the amount of the project was significantly reduced.

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

- Improving the environmental quality, public health, and safety of California's electricity by developing a roadmap for integrated sustainable urban energy planning that takes into account energy, environmental, health and safety concerns, business, quality of life, and other community needs.

### **Proposed Outcome:**

1. Develop a roadmap that identifies appropriate tools and methods that will support California's local and regional governments in effectively engaging in sustainable urban energy planning with the objectives of reducing the environmental costs of energy production, transmission, and use, and reducing the use/depletion of scarce resources. Projects that will ultimately be supported may also address improving energy efficiency, reducing per capita electricity consumption, and/or facilitating the achievement of the Renewable Portfolio Standard at the local and regional level.

### **Actual Outcome:**

1. The draft roadmap is complete and will be sent out for stakeholder review in January 2005. Comments will be incorporated into the roadmap in February.

### **Project Status:**

The project is expected to be complete by March 2005.

## **The Environmental Impacts & Economic Potential of Novel Hydrogen-Renewable Infrastructure**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** University of California, Berkeley

**Project Amount:** \$74,898

**Contractor Project Manager:** Daniel Kammen (510) 642-1139

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Active

### **Project Description:**

The purpose of this project is to develop a tool to study the life cycle environmental impacts and economics of hydrogen production and fuel cell or hydrogen generator-based power.

California's renewable portfolio standard (RPS) requires the State's electricity generating companies to produce or purchase 20% of the electricity they sell from renewable technologies by 2017. Technologies such as wind turbines and photovoltaics (PV) are poised to contribute substantially in meeting this goal, however, the widespread acceptance and use of these technologies is hindered by their inability to provide power when the wind is not blowing or the sun is not shining. To become competitive with fossil and hydroelectric power plants, their electricity must be stored, so that it can be dispatched at any time.

Hydrogen provides an excellent storage medium for the energy generated by intermittent renewable technologies. It can be produced by renewable technologies whenever they are operating. Then it can be stored, transported, and used to generate electricity in a fuel cell. To begin to reap the benefits of renewables and this energy storage method, research must identify the life cycle environmental impacts and economics of the production and use of hydrogen from renewable technologies.

Researchers will examine the ways that hydrogen storage can facilitate renewable energy systems (particularly wind and PV) likely to be built to fulfill the RPS. They will: (1) identify 4 sites in California that are likely to experience significant growth in renewable wind and PV power generation under the statewide RPS and (2) perform environmental and economic life cycle analyses of various combinations of renewable power and storage/supplemental power systems, in the context of those sites.

To perform those analyses, researchers will use the Hybrid Optimization Model for Electric Renewables (HOMER) model developed by the National Renewable Energy Laboratory, so that it can conduct environmental and economic analysis of various renewable power generation and energy storage systems. The model will be modified to include hour-by-hour characterizations of the four California wind sites and additional input data to characterize hydrogen production/storage and lead acid and zinc-bromine flow battery energy storage systems.

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

- Providing environmentally sound electricity by helping researchers identify the impacts of hydrogen production as an energy storage medium for renewable electricity generation, relative to other energy storage technologies. As a result, future technologies employing hydrogen may be assisted in providing optimal environmental benefits from the outset. By facilitating the development of hydrogen as an energy storage medium, this project is expected to encourage the development of emissions-free renewable technologies throughout the State.

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- Providing reliable electricity by furthering the development of hydrogen and other energy storage for renewables, which will help California to deliver a sufficient amount of electricity to end users as the population and economy grows.
- Providing affordable electricity by diversifying the State’s electricity feedstock base with renewables-produced hydrogen and thus helping to insulate consumers against natural gas price swings. As the use of natural gas as a fuel for power generation and heating becomes more widespread, its price is predicted to rise.

### **Proposed Outcome:**

1. Researchers will be able to use the modified HOMER model to conduct environmental and economic analysis of various renewable power generation and energy storage systems. This modeling will help identify sites in California where the renewable technologies are likely to expand and characterize the environmental and economic implications of incorporating hydrogen storage into those scenarios.

### **Project Status:**

The Final Report will be completed in 2005 and results will be summarized in the 2005 Annual Report.

## Trihalomethane Formation in Treated Cooling Water

**Contract #:** 100-98-001 **Project #:** 44

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

**Project Amount:** \$117,000

**Match Amount:** \$58,350

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Active

### **Project Description:**

The purpose of this project is to evaluate existing literature and identify the important parameters of trihalomethane (THM) formation. Most power plants that employ wet cooling systems use chlorine in those systems to prevent biofouling, and this chlorine use raises concerns that individuals who work around these systems could receive harmful exposure to THMs, particularly through inhalation. Several studies of THM formation from intermittent chlorination of once-through cooling water indicated that resulting levels might be high enough to present human health concerns; however, little or no research has been conducted to study THM formation in wet cooling towers that employ continuous chlorination.

Of special concern is chlorination of recycled water since it contains higher levels of organic carbon compounds than most freshwater supplies, which may lead to an even greater THM formation rate. California has mandated that recycled water be used for cooling when available, so recycled water, which is tertiary treated effluent from wastewater treatment plants, is increasingly being used for power plant cooling. Because California lists several of these THM compounds as carcinogenic and recognizes that long-term exposure to these compounds may also cause liver, kidney and nervous system damage, it is essential that research establish safe practices for using recycled water.

To address THM concerns, the PIER Environmental Area (PIEREA) Team and the Electric Power Research Institute (EPRI) are evaluating the existing literature and identifying the important parameters of THM formation (i.e., the type of organic compounds present, likely resulting concentrations, potential pathways and resulting human health risks). The project team is also evaluating alternative oxidizing biofouling compounds and their effect on THM formation. The final report will identify the potential for THMs to be created from wet cooling systems that use chlorine and the best management practices that can be used to lessen potential health risks from cooling water treatment leading to THM formation.

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

- Providing environmentally sound and safe electricity by identifying and addressing THM risks. This project helps to ensure that electricity is produced without risks to public health.
- Improving the health costs/risk of California's electrical system by quantifying the risk and identifying factors to mitigate this risk. This project will increase the acceptance of using reclaimed water in power plant cooling systems, which will free potable water sources for other uses.

### **Proposed Outcome:**

1. Safe use of recycled water for power plant cooling. The Energy Commission recently certified two facilities, totaling 1380 MW, which will use recycled water for cooling. It is anticipated that additional projects slated to use recycled water (totaling thousands of

additional megawatts of generation capacity) will be proposed in the future. This research will enable power producers to operate effective cooling systems without risking the health of their workers.

**Actual Outcome:**

1. The project concluded that THM is formed during halogenation in the two cooling towers studied and that most of the THM escapes from the cooling tower in the air stream. For the cooling tower where intermittent chlorination is practiced, only minor levels of THM were formed and these amounts attenuated to non-detectable levels within several hours. For the cooling tower where continuous chlorination is practiced, detectable levels of THMs were created on a continuous basis. At both sites, calculated air stream concentrations of total THMs were very low and far below workplace health threat levels established by OSHA for chloroform.

**Project Status:**

The project is complete.

Final Report Title: The Formation and Fate of Trihalomethanes in Power Plant Cooling Water Systems

Commission Publication Number: 500-04-035

Publication Date: May 2004

PIER Web Location: [www.energy.ca.gov/pier/final\\_project\\_reports/500-04-035.html](http://www.energy.ca.gov/pier/final_project_reports/500-04-035.html)

## Urban Heat Island Modeling

**Contract #:** 500-02-013

**Contractor:** Haider Taha

**Contract Amount:** \$140,798

**Contractor Project Manager:** Haider Taha (925) 285-5221

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Active

### **Project Description:**

The goal of this project is to update and use state-of-the-science meteorological and air quality models and recent meteorological and air-quality/emission data to develop a scientifically sound urban heat island modeling system and to conduct modeling for the Sacramento Valley, San Francisco Bay Area, North and South San Joaquin Valley, and the South Coast Air Basin. To ensure usability, the modeling is designed and done to support the needs and criteria of the U.S. Environmental Protection Agency (EPA), California Air Districts, and the California Air Resources Board (ARB).

Urban heat islands typically occur in developed areas that absorb and retain solar heat as well as generate their own. As a result, they require additional cooling (which raises energy demand) and suffer from increased ground-level ozone, or smog, with harmful effects on human health. One study estimated that the increased cooling necessary to counterbalance the heat island effect in Los Angeles costs local ratepayers \$100 million each year, and other studies have shown that higher temperatures can cause local smog concentrations to rise sharply.

To bring broad-based expertise to this work, a Project Advisory Committee (PAC) composed of a diverse group of air quality professionals will guide research, review deliverables, evaluate benefits, and recommend ways to enhance benefits and strategies for communicating results and commercializing this project's products.

The modeling will use 200-meter LULC (Land Use and Land Cover) data from the United States Geological Survey and recent air quality and emission data from the 1997 Southern California and 2000 Central California Ozone Studies. The meteorological modeling of selected episodes and domains for the airsheds mentioned above, will be done using the latest generation of the Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) MM5 model. The model outputs from these runs will serve as input to emission and air quality models, and meteorological results will also be used to estimate the large-scale impacts of heat island control on energy use in California.

Emission models will be used to recast air-pollutant emission rates to reflect changes in the simulated meteorological conditions, and will account for emissions from anthropogenic sources as well as existing vegetation and vegetation that could be planted to reduce heat in the area. For the air quality modeling component of this study, the CAMx (Comprehensive Air Quality Model with extensions) photochemical model will be used to simulate baseline conditions and all heat island reduction scenarios.

### **The project supports the PIER Program objective of:**

- Improving the Environment and Public Health Costs/Risk of California's Electricity by quantifying the potential energy and air quality benefits of heat island reduction and by providing the Commission, ARB and California Air Quality Management Districts with

recommendations and a basis to adopt these strategies. It will also allow for consideration of potential tradeoffs with other strategies (such as emissions controls), or supplement these other strategies to help reach/maintain attainment status with respect to ozone.

### **Proposed Outcomes:**

1. This research will help planners mitigate the meteorological and air-quality effects of urbanization and urban heat islands, where they exist, by enabling them to model different strategies and scenarios to find the most effective combination of solutions. If temperatures of urban areas are lowered, less electricity will be needed to power cooling systems and power plant emissions will be reduced. One study found that a temperature reduction of just 5°F in Los Angeles could reduce smog concentrations in the area, and another found that the energy savings from changing roof reflectivity would amount to \$35 million per year.
2. The modeling will conform as much as possible to the configurations, domains, and episodes used by California Air Quality Management Districts in their State Implementation Plan (SIP) demonstration modeling and by the ARB. Air-quality modeling results will be converted into nitrogen oxides (NO<sub>x</sub>) and/or volatile organic compounds (VOCs) emission-reduction equivalence metrics that can then be used to estimate the benefits of heat island control more directly. In addition, the results will be translated into SIP-specific or EPA-approved metrics that can be directly incorporated into SIPs or related incentives in the future.
3. Overall, the results of this work will help air quality management districts reach or maintain attainment status for ozone air quality.

### **Project Status:**

Thus far, this study has focused on model modification and updates and model performance evaluation. In addition, regional land-use characterization and land-use modification scenarios have been developed. Meteorological and photochemical simulations of both the Central California (CCOS) and southern California (SCOS) scenarios were performed. Biogenic hydrocarbon (i.e., isoprene) emissions for both the CCOS and SCOS component of this study were updated to correspond to the modified meteorological conditions of each scenario. Results from photochemical simulations of each scenario are currently being evaluated and converted into various metrics to assess the effectiveness of urban environmental control (“cool city”) strategies in modifying ozone concentrations and improving air quality in California. Three Project Advisory Committee meetings have been held to update the research community of the progress and to gather input on the appropriate next directions. Preliminary results show up to 2 parts per billion (ppb) change in ozone for urban areas with significant heat island strategies (i.e. adding 45 trees per large urban block or modifying several hundred thousand rooftops in a city). Heat Island Effects appear to be more effective at reducing ozone in the Central Valley compared to Southern California. The final report on the results of this work will be available in summer 2005.

## West Coast Regional Carbon Sequestration Partnership

**Contract #:** 500-02-004 WA021/ 500-02-014 WA 109/ 500-03-018

**Contractor:** California Institute for Energy Efficiency (CIEE), the Electricity Innovation Institute (E2I), and the California Department of Conservation (DOC)

**Contract Amount:** CIEE: \$1,010,097 (DOE: \$400,000; PIER: \$610,097); E2I: \$651,000 (DOE: \$511,000; PIER: \$140,000); DOC: \$130,000

**Match Funding:** \$734,000 (DOE \$470,000; British Petroleum \$80,000; Kinder Morgan \$99,000; Oregon Department of Forestry \$85,000)

**Contractor Project Managers:** (CIEE) Carl Blumstein (510) 643-0505, (E2I) Dale Eldredge (650) 855-1098, (DOC) John Clinkenbeard (916) 323-7696

Commission Contract Manager: Guido Franco (916) 654-3940

**Status:** Active

### Project Description:

The California Energy Commission is leading the West Coast Regional Carbon Sequestration Partnership (WESTCARB)—one of seven regional partnerships established by the U.S. Department of Energy in August 2003. The partnership is a consortium of over forty organizations including:

- State natural resource and environmental protection agencies.
- National labs and universities.
- Private companies working on carbon dioxide (CO<sub>2</sub>) capture, transportation, and storage technologies.
- Utilities.
- Oil and gas companies.
- Nonprofit organizations.
- Policy/governance coordinating organizations.

Phase I of these partnerships focuses on developing regional frameworks to validate and implement the carbon sequestration technologies most appropriate for each region. In this project, PIER Environmental Area (PIER-EA) and the U.S. Department of Energy are funding research to evaluate carbon capture, transport, and sequestration (CT&S) for the WESTCARB region, which consists of California, Washington, Oregon, Arizona, Nevada, Alaska and British Columbia. The U.S. portion of the region is responsible for more than 11% of the human-caused carbon dioxide (CO<sub>2</sub>) emissions in the United States, where in 2002 CO<sub>2</sub> emissions rose 0.8% over the previous year.

Carbon emissions such as those from fossil fuel power plants accumulate in the atmosphere, and can last from 50 to 200 years, increasing the Earth's temperatures, altering the climate, and subsequently affecting water supply and quality, human health, agricultural production, habitat viability, the length and intensity of weather events, and ultimately, our entire environment, economy, and quality of life. However, carbon is naturally cycled out of the atmosphere into vegetation, land, and water bodies, and sequestration of atmospheric carbon into these "sinks" can be planned and encouraged through various activities.

Although climate change is not a local phenomenon, many of its effects are. The type and extent of climate change impacts to a state or region depend on such factors as topography, proximity to an ocean, vegetation types, sources of water, and others. For some of the western states, many of the impacts are similar, as are many of the solutions. There is a commonality in terrestrial sinks in Washington, Oregon, and Northern California and a commonality and large potential capacity in geological sinks in California, Nevada, and Arizona. By taking a regional approach to researching

these issues and solutions, these western states can leverage the resources, funding, and expertise in the region to achieve regional solutions to climate change issues.

Phase I consists of five key tasks:

1. Collect data to characterize major CO<sub>2</sub> point sources, the transportation options, and the terrestrial and geologic sinks in the region.
2. Compile and organize this data via a geographic information system (GIS) database.
3. Address key issues affecting deployment of CT&S technologies, including storage site permitting and monitoring, injection regulations, and health and environmental risks.
4. Conduct public outreach and maintain an open dialogue with stakeholders in CT&S technologies through public meetings, joint research, and education work.
5. Integrate and analyze data and information from the above tasks to develop supply curves and cost-effective, environmentally acceptable sequestration options, both near- and long-term.
6. Identify appropriate terrestrial and geologic demonstration projects consistent with the options defined above, and create action plans for their safe and effective implementation.

The California Institute for Energy Efficiency (CIEE) and its subcontractors are managing the Partnership's technical work, preparing baselines and supply curves for regional terrestrial sequestration opportunities, characterizing potential sites for geologic sequestration in Nevada, compiling and assessing regulations and permits, conducting public outreach, and providing GIS support. The Electricity Innovation Institute (E2I) and its subcontractors are compiling point source and transportation data, and performing economic and other analyses to define the best geologic sequestration options. The California Department of Conservation (DOC) is coordinating geologic characterization activities and assessing potential geologic sequestration sites in California. All these activities incorporate and build upon PIER's efforts to date to determine the least-cost options for terrestrial and geologic carbon sequestration.

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

- Improving the energy cost/value of California's electricity by determining the most appropriate least-cost carbon sequestration options. These projects will help provide the State with economical tools for reducing atmospheric carbon and addressing potential state and national limits on CO<sub>2</sub> emissions.
- Improving the environmental and public health cost/risks of producing electricity by identifying effective methods for sequestering carbon, which will contribute toward mitigating the effects of using carbon-based fuels for electricity production. In addition, some methods, such as no-till agriculture and restoring rangelands and wetlands, will contribute to overall environmental and habitat health.

### **Proposed Outcomes:**

1. Improved knowledge of the potential for carbon sequestration in the participating western states.
2. GIS database of major CO<sub>2</sub> point sources, transportation options, and terrestrial and geologic sinks in the region.
3. Analysis of storage site permitting and monitoring, injection regulations, and health and environmental risks as they relate to the deployment of CT&S technologies supply curves and near- and long-term, cost-effective, environmentally acceptable sequestration options.
4. Action plans for the implementation of terrestrial and geologic demonstration projects.
5. Public outreach and education on the issue of carbon sequestration in the region.

**Project Status:**

Work is underway and the final report on the results of this work will be available by the spring of 2006.

## **ENV Projects Completed in 2004**

**Backup Generators/Distributed Generation Air Quality Methodology Study  
(Phase II)**

**Contract #:** 500-00-032

**Contractor:** University of California, Riverside

**Subcontractors:** NN Consulting

**Contract Amount:** \$1,500,000

**Contractor Project Manager:** James Lents (909) 781-5742

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Completed

**Project Description:**

The purpose of this project was to develop a methodology to assess and quantify the air quality impacts of backup generators (BUGs), and verify that methodology on the BUGs operating in California. This project estimated the air quality impacts of rolling blackouts in 2001 and identified particulate matter (PM) reductions from use of emissions controls. The project focused primarily on BUGs, but the methodologies developed are applicable for analyses of more general distributed generation (DG) technologies when and where appropriate.

Diesel exhaust is a complex mixture of inorganic and organic compounds that exist in gaseous, liquid, and solid phases. Over 90 percent of the mass of these particles are less than 2.5 microns in diameter. Because of their small size, these particles are easily inhaled into the bronchial and alveolar regions of the lung. Diesel exhaust includes over 40 substances that are listed as hazardous air pollutants (HAPs) by the U.S. EPA and by the California Air Resource Board (CARB) as toxic air contaminants (TACs). In addition, the CARB identified PM from diesel fuel engines as toxic air contaminants and found that long-term occupational exposures to diesel exhaust was associated with a 40 percent increase in the relative risk of lung cancer.

Researchers conducted field tests of BUGs to collect important baseline emissions data and operated BUG units with alternative fuels and PM exhaust after treatment technologies to quantify the potential benefits from these fuels and technologies. The project also reviewed already developed BUG inventory data. These data were used in atmospheric modeling to assess the air quality impacts of BUGs. This effort was coordinated with CARB.

Determining how these technologies can be used and dispatched to generate more power with less environmental impact will support the implementation of these technologies in California, which will increase overall generation capacity in the State and promote the greater use of appropriate DG technologies.

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

- Improving environmental and public health costs/risk from California's electricity system by providing quantifiable objective data for decision makers concerning potential adverse air quality impacts from the use of significant numbers of BUGs. It also provides appropriate data for decision-makers concerning techniques to mitigate likely air quality impacts associated with the use of BUGs and the effectiveness and durability of PM controls in reducing emissions.

**Proposed Outcome:**

1. Develop standard methodologies will promote a clean environment and public health. Standard methodologies will enable regulators and researchers to improve the environmental and public health aspects of generating California's electricity through

sound evaluations of PM emission control technologies, air quality impacts of BUGs and other DG technologies.

### **Actual Outcomes:**

1. **Air Quality Implications of Backup Generators in California - Volume One: Generation Scenarios, Emissions and Atmospheric Modeling, and Health Risk Analysis.** Publication No. CEC-500-2005-048. This volume describes the methodology developed to evaluate air quality impacts of distributed energy sources or BUGs, and reviews the use of BUGs during the 2001 power blackouts to determine the actual use of BUGs when electricity was curtailed. This evaluation serves as the basis for estimating air quality impacts during the actual blackouts and as an indicator of the potential air quality impacts of the use of BUGs during future blackouts. This volume also presents the results of estimates of the air quality impacts of BUGs based on several scenarios of widespread BUGs use in California. Both the local and regional impacts of BUGs are evaluated using the latest modeling techniques.
2. **Air Quality Implications of Backup Generators in California - Volume Two: Emission Measurements from Controlled and Uncontrolled Backup Generators.** Publication No. CEC-500-2005-049. This volume presents the results of the measurement of emissions from a series of actual in-use BUGs selected from different age and size groups. Available controls were applied to some of the BUGs and the effectiveness of these controls measured. Volume II reports the results of the measurement of both the as is BUGs and emission results with different available controls added. Finally, the impact of the use of water emulsified fuel in a BUG was measured and reported on in the second volume. Information developed in this project has been used by the CARB when developing the Airborne Toxic Control Measure for Stationary Compression Ignition Engines.
3. Modeling of exposure to particulate matter as a result of hypothetical uncontrolled BUGs operation found that all scenarios for both large and medium BUGs produce maximum cancer risks greater than 10 in a million—a common regulatory limit for permitting. Direct mortality from exposure to PM<sub>2.5</sub> from BUGs was not estimated because of the lack of consensus on estimates of the direct mortality risk associated with PM<sub>2.5</sub>. However, it is possible that direct mortality risks could be a significant concern.
4. Air quality modeling for ozone (O<sub>3</sub>) indicates that nitrogen oxides (NO<sub>x</sub>) emissions from uncontrolled BUGs can have a substantial impact on air quality, with reductions in O<sub>3</sub> near the BUGs source but increases in O<sub>3</sub> further downwind. Ozone levels decreased by 10 parts per billion (ppb) or more near the source because of nitric oxide (NO) titration of O<sub>3</sub> and nitrogen dioxide (NO<sub>2</sub>) scavenging of hydroxyl free radicals, but O<sub>3</sub> levels increased downwind because the transported NO<sub>x</sub> caused greater O<sub>3</sub> production.
5. Emissions were measured from controlled and uncontrolled BUGs. This information was used by the CARB when developing the Airborne Toxic Control Measure for Stationary Compression Ignition Engines that identifies levels of particulate matter control required for various operation times of diesel engines.

### **Project Status:**

This project has been completed. The results of the research are available in two volumes noted above.

## Central California Ozone Study

**Contract #:** 700-98-027

**Contractor:** California Air Resources Board (CARB)

**Contract Amount:** \$3,000,000

**Match Amount:** \$441,000

**Contractor Project Manager:** Ajita Kaduwela (916) 327-3955

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Completed

### Project Description:

The purpose of this project was to participate, through an interagency agreement with the California Air Resources Board (CARB), in the Central California Ozone Study (CCOS) to gain a better understanding of the dynamics of the existing and future ozone problem in central California. Other participants in this study include several local air districts, the U.S. Environmental Protection Agency (EPA), and private entities. The results of this study are being used to identify the control strategies to be used in this region of California.

The purpose of CCOS is to better understand the formation of ozone in central and portions of northern California. The study domain extends from Redding in the north to the Mojave Desert in the south and from the Pacific Ocean in the west to the Sierra Nevada in the east. A large portion of the area being studied is non-attainment for state and federal ozone standards. The study consists of field measurement, data analysis, emissions inventory development, and air quality modeling. This information is being used in the development of the State Implementation Plans (SIPs) for ozone. The field study was conducted during the summer of 2000 and an emissions inventory was generated. Data analysis and modeling are in progress.

The comprehensive CCOS database provides an opportunity to support future SIPs from three episodes captured during the CCOS field study. The development of this information and modeling tools will also provide the opportunity to study new ways to use electricity to avoid or reduce air quality problems in this region.

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

- Improving the public health costs/risks of California's electricity by promoting a better understanding of the dynamics of the existing and expected ozone problem in central California.

### Proposed Outcome:

1. Gain a better understanding of the dynamics of the existing and future ozone problem in central California.

### Actual Outcomes:

1. The establishment of a comprehensive database of the ambient measurements of meteorology and air quality. This database is the largest and most comprehensive database in California.
2. Significant improvement of the modeling emissions inventory.
3. Evaluation of two meteorological and three air quality models.
4. This study allowed the simulations of more than one ozone episode. This contrasts with past SIPs where preparation was based upon information obtained only from simulations of a single ozone episode. Preparation of the 1-hour ozone SIP for the San Joaquin Valley non-attainment area is based on information obtained this study.

5. Advanced our understanding of the impacts of power plant plumes on the air quality in central California. The modeling studies indicated that the impact of these plumes on air quality was minimal to moderate, but far less than that observed in the eastern USA.

**Project Status:**

This project is complete. The draft final report is being reviewed by staff and should be available first quarter, 2005.

## **Developing Methods to Reduce Bird Fatalities in the Altamont Pass Wind Resource Area**

**Contract #:** 500-01-019

**Contractor:** BioResource Consultants

**Contract Amount:** \$420,670

**Contractor Project Manager:** Carl Thelander (805) 646-3932

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

### **Project Description:**

The purpose of this project is to complete the avian fatality surveys in areas of the Altamont Pass Wind Resource Area (APWRA) not previously surveyed and to develop a model to identify and reduce collision risk to birds in the APWRA. Such a model will be a valuable tool for siting new or repowered turbines so that reductions in bird fatalities are achieved. Once repowering has occurred, the project will also investigate the effects of these larger, more efficient turbines.

The collision of birds with wind turbines has been documented since the early 1980's and recent findings conservatively estimate that at least 1,000 or more birds, mainly raptors, are being killed annually. Laws protecting birds include the Migratory Bird Treaty Act, the Bald Eagle and Golden Eagle Protection Act, and the federal Endangered Species Act. Violations can result in fines from \$100,000 to \$500,000. Also, Alameda County will not approve additional permits to increase current electricity production at the APWRA until significant progress toward solving the bird fatality issue is demonstrated. Efforts to repower the Altamont Pass and other wind resource areas in the State with larger, greater megawatt capacity turbines have begun without quantifying the effects of these turbines on birds or a thorough understanding of whether they will reduce bird fatalities.

From 1998 to 2001, BioResource Consultants (BRC), under contract to the National Renewable Energy Laboratory (NREL), has been investigating bird fatalities at the APWRA. According to this work, about 25 percent of the turbines are responsible for 100 percent of the fatalities. It appears that certain topographic features, prey density, and turbine placement factors contribute to avian collision. BRC is applying these data to develop a risk sensitivity model that can be used to determine locations within the APWRA of high, moderate, and low risk to birds. To date, only a small portion (20%) of the APWRA has been surveyed. Additionally, the area surveyed to date does not contain the turbine type that is most abundant in the APWRA.

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

- Improving the energy cost/value of California's electricity by siting the new, more efficient turbines in low risk locations, resulting in fewer bird fatalities, more megawatts per turbine and reduced maintenance costs.
- Improving the environment, public health and safety by developing a tool that can provide a realistic and cost effective solution to the bird collision problem.
- Providing greater choices for California consumers by providing a tool that can show a significant reduction in turbine-caused avian fatality, thereby allowing Alameda County to approve permits for an increase in productive capacity.

### **Proposed Outcomes:**

1. Quantify bird use, including characterizing and quantifying perching and flying behaviors of individual birds around wind turbines evaluate flight behaviors and the environmental and topographic conditions associated with them, and identify possible relationships

between bird mortality and bird behaviors, wind tower design and operations, landscape attributes, and prey availability.

2. Develop predictive empirical models that identify turbine or environmental conditions that are associated with high vulnerability.
3. Aid the siting of any new turbines in locations and in arrangements that will result in fewer bird kills.
4. Assist the wind industry and the County of Alameda bring the APWRA into compliance with state codes and federal laws pertaining to existing violations.

**Actual Outcomes:**

1. Quantified bird use, including characterizing and quantifying perching and flying behaviors of individual birds around wind turbines; evaluated flight behaviors and the environmental and topographic conditions associated with them; and identified possible relationships between bird mortality and bird behaviors, wind tower design and operations, landscape attributes, and prey availability.
2. Developed predictive empirical models that identified turbine or environmental conditions associated with high vulnerability.
3. Developed a tool to help site any new turbines in locations and in arrangements that would result in fewer bird kills.
4. Developed mitigation measures and recommended procedures that if implemented would assist the wind industry and the County of Alameda bring the APWRA into compliance with State codes and federal laws pertaining to existing violations.

**Project Status:**

A detailed technical report, publication number P500-04-052, was released August 2004.

The study estimated that between 881 to 1,300 raptors and 1,766 to 4,721 birds are killed annually from collisions with wind turbines at the Altamont Pass Wind Resource Area.

The researchers found:

- Certain land management practices appeared to attract birds closer to turbines.
- Certain areas of the landscape are more dangerous than others.
- End turbines, gaps in turbines and isolated turbines kill disproportionately more birds.
- Turbines placed on towers tall enough for the lowest blade reach to be 29 meters above ground would avoid a significant proportion of bird flights and therefore likely reduce potential for collisions.

Research is being used to develop mitigation plans, permit requirements and in siting new turbines in lower collision-potential locations.

## **Fine and Ultrafine Particulate Study**

**Contract #:** 700-00-002

**Contractor:** Gas Technology Institute

**Subcontractors:** GE Energy and Environmental Research Corporation

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

**Match Amount:** \$568,800

**Contractor Project Manager:** Paul Drayton (847) 768-0694

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Completed

### **Project Description:**

The purpose of this project was to develop a more accurate and precise particulate matter (PM) reference test method for measuring PM emissions from combustion sources. Epidemiological and animal studies have found an association between the concentration of PM in ambient air and illness and mortality. Additionally, studies have determined that fine particles (particles less than 2.5 microns) are more closely correlated with adverse health effects than larger particles. One leading hypothesis claims that ultrafine particles (particles less than 0.1 micron) or particular compounds produced or released during combustion processes could be a significant cause of health problems. Particulates can lead to increased hospital and doctor visits, decreased lung function, and aggravated respiratory problems. Moreover, if newborns and young children inhale particles with toxic air contaminants, those particles could affect the development of their respiratory, nervous, endocrine, and immune systems, and could increase cancer risk later in life.

PIER collaborated with the Gas Technology Institute (GTI) and New York State Energy Research and Development Authority (NYSERDA) in an attempt to develop an accurate PM reference test method for measuring particulate emissions (fine, ultrafine, and particulate matter up to 10 micrometers in size (PM10)) from combustion sources. Researchers tested these new methods in several full-scale power-generation related combustion sources and in other sources. This project also developed realistic mass emission rates, ultrafine emission counts, and emissions profiles to provide a basis for sound emission inventories and future regulations. A technical advisory committee helped ensure that the project was coordinated with other efforts and that the research products were of the highest technical quality.

Researchers conducted a comprehensive literature review and a survey of research institutions and relevant regulatory agencies to define and document the state of the art in PM testing. Based on the issues identified in the literature search, researchers developed an improved method to collect and preserve PM samples so that their chemical constituents can be chemically analyzed. The research provides complete emission profiles (speciated PM, speciated volatile organic compounds (VOCs), nitrogen oxides (NO<sub>x</sub>), nitric oxide (NO), Nitrogen dioxide (NO<sub>2</sub>)). The methods developed will influence future California mitigation strategies and help characterize the risk posed by combustion gas turbine projects proposed before the Energy Commission.

Accurate data will contribute to PM health studies. The methods and data produced by this work may help advance research into the health effects caused by various sizes of particulate matter. PM regulations can be based on better scientific data. By improving PM sampling and analyses, PM regulations can be better targeted to address the PM emissions levels deemed harmful. More accurate PM data will enable power suppliers to assess and report PM emissions accurately. If power producers do not have to overestimate PM emissions, it will be easier to find offsets in a

limited offset environment. As a result, it will be easier to build environmentally acceptable generating facilities.

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

- Improving environmental and public health costs/risks by enabling regulators to realistically assess the environmental impacts of generating electricity and to mitigate adverse impacts based on accurate measurements of the size and amount of particulate matter emitted from power plants.
- Improving the reliability/quality of California's electrical system by providing power producers with accurate scientific data to assess emissions from power production processes. This will reduce cost and increase California's electrical system reliability by allowing generating plants to produce electricity while ensuring that PM control is consistent with the actual PM emission profile of individual power plants.

**Proposed Outcome:**

1. Develop a more accurate and precise particulate matter (PM) reference test method for measuring PM emissions from combustion sources.

**Actual Outcomes:**

1. A compact dilution sampler was designed and tested in this project. Detailed operating procedures evolved during the course of the program as weaknesses and problems were identified. Procedures are generally adequate for research purposes. Dilution sampling indicates PM 2.5 mass emissions from gas-fired sources are extremely low, probably near ambient air PM 2.5 concentrations in many cases.
2. Significant advancements were achieved in both the technology of dilution sampling and source emission characterization. However, further work is needed to improve dilution method and validation and additional sources testing is needed to develop more robust emission factors and speciation profiles.

**Project Status:**

This project is complete. Besides the main report, there are 12 companion reports including a review of literature, technical reports and site test reports.

Final Report Title: Development of Fine Particulate Emission Factors and Speciation Profiles for Oil- and Gas-fired Combustion Systems.

Publication Numbers: CEC-500-2005-032 to CEC-500-2005-044

PIER Web Location: [www.energy.ca.gov/pier/final\\_project\\_reports/CEC-500-2005-032\\_to\\_44.html](http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-032_to_44.html)

**Measurement, Classification, and Quantification of Carbon Market Opportunities in the United States: California Component (2002) CF Program 48**

**Contract #:** 100-98-001 **Project #:** 51

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

**Subcontractors:** Winrock International

**Project Amount:** \$363,000

**Contractor Project Manager:**

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Completed

**Project Description:**

The purpose of this project is to classify, quantify, and measure carbon market opportunities for land use change and forestry activities that could be implemented in the State of California. The resulting information will enable companies and organizations in California to make better decisions on how to participate in carbon markets that may emerge under future regulatory regimes.

The work has three major components:

- Development of a baseline for the State that shows how carbon stocks in vegetation and soils have changed over the past decade.
- Classification of the major opportunities for carbon storage on the land within the State and improved data on the quantity and costs of carbon storage for major classes of land-use and forest-based projects in California.
- Measurement services for carbon storage opportunities in California enabling accurate and precise estimation of the quantity of credits available from selected classes of projects.

This project complements, but is separate from, the Electrical Power Research Institute's (EPRI) Collaborative Carbon Initiative for measurement, classification, and quantification of carbon market opportunities in the United States. The EPRI initiative aims to improve the quality of information and analytical tools available to participants who wish to prepare for an uncertain future with respect to carbon dioxide limitations. This California specific component of the initiative will draw upon a wide range of public data.

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

- Improving the environmental costs/risks of California's electricity by developing information and tools to support cost-effective approaches for carbon dioxide management.

**Proposed Outcomes:**

1. Perform measurement and design of monitoring activities to assess carbon credits from carbon storage projects in California. This will include developing a baseline of carbon emissions and/or sequestration in the land use and forestry sector of California for the period of 1990-2000, including identification and quantification of the magnitude of carbon sources and sinks. The project team will also perform measurement and design of carbon monitoring activities in California for one or more categories of potential carbon projects, including changes in forest management to increase large trees, fire management, reforestation of riparian ways, and conversion of grazing lands.

2. Develop a classification system for carbon storage opportunities in California, including a detailed analysis for one county. The project team will:
  - Prepare carbon supply curves for the major classes of potential land-use and forest-based activities in California in a format that allows comparison with opportunities in other regions.
  - Prepare detailed supply curves for carbon storage opportunities for one county using data available for individual parcels.
  - Prepare carbon supply curves for carbon storage opportunities within the agricultural sector that may not be significant at the state level but could be important at the county or regional level.
3. Expand a database being developed under the Collaborative Carbon Initiative to allow for a preparation of carbon supply curves for biomass energy and estimation of carbon credits that would result from decreased energy use associated with urban forestry projects.

**Project Status:**

During 2002, work focused on the development of the state baseline and data collection and analysis of the major carbon storage opportunities. Measurement and monitoring work will begin in 2003 pending identification of priority projects for measurement.

For the baseline, Winrock has collected and evaluated available geographic data against a variety of criteria: resolution, extent, collection date, future availability and cost. Winrock is working closely with the California Department of Forestry and Fire Protection's Fire and Resource Assessment Program to identify the advantages and disadvantages of various datasets. Preliminary comparisons of the various data sources have been done for Yolo and Sacramento counties to illustrate how the choice of datasets will affect results.

Classification and quantification of carbon storage opportunities began with collection and organization of appropriate economic data and development of habitat suitability maps derived from the Natural Resource Conservation Service's STATSGO databases to identify areas best suited for specific activities (grains, woodlands, rangelands, etc.). Economic data and land suitability maps will be combined with other data to produce supply curves for carbon credits in 2003.

## Monitoring Systems for Studying Avian and Wildlife Interactions with Power and Communication Facilities

**Contract #:** 100-98-001 **Project #:** 47

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

**Subcontractors:** EDM International, Inc.

**Project Amount:** \$100,000

**Match Amount:** \$100,000

**Contractor Project Manager:** Rick Carlton (650) 855-2115

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

### Project Description:

The purpose of this project is to mitigate and reduce avian fatalities and increase power reliability. Avian interactions (i.e. collisions and electrocutions) with overhead power lines, wind turbines, communication towers, and other utility structures can disrupt service and/or adversely affect bird populations. Current analyses estimate that birds cause approximately 25% of all U.S. outages. These outages can cost a utility \$500,000 annually in lost revenue and \$250,000 annually in repair. Heightened awareness of the problem has spurred efforts to develop ways to avoid avian interactions with California's electrical infrastructure, thereby increasing power reliability throughout the State.

PIER Environmental Area (PIER-EA) and Electrical Power Research Institute (EPRI) are developing and testing automated avian monitors to (1) address the need to gather collision and electrocution information that is difficult and costly to obtain, (2) help standardize monitoring methods, and (3) evaluate the efficacy of bird deterrent devices. These monitors can be used in remote locations and could result in considerable cost savings by reducing time and personnel in the field. Aside from automated data gathering, one advantage of these monitors is that their documentation of avian interactions and fatalities is accurate and occurs in real time. Currently, avian mortality estimates are based on dead-bird searches that are conducted by personnel on the ground. Numerous biases are involved, including search bias (differences among individual searchers), habitat bias (carcasses hidden by ground cover), and scavenging bias (carcasses removed by scavengers before being counted). Automated monitoring systems for bird strikes and other avian interactions can document the interaction and notify appropriate persons, enabling rapid responses that can reduce biases.

The efficacy of these automated monitoring systems must be gauged against the established methods of dead-bird searches. To that end a field site was chosen for conducting background dead-bird searches while the R&D effort began on the monitoring hardware.

This project consists of four separate tasks that are integrally related, although each task can stand alone and supply its own deliverable:

1. Beginning late in 2000, the research team developed a dead-bird search protocol. The protocol was based on existing protocols, and was modified for the particular field situation chosen for this study. Briefly, the field site is a 3.5-mile-long transmission and distribution corridor in North Dakota (> 20 wires per span) that separates an Audubon Wildlife Preserve from a lake that is used daily by birds from the preserve. Based on anecdotal information it was estimated that several hundred bird fatalities per year were occurring at this site.
2. The Bird Strike Indicator (BSI) is an impulse-based vibration sensing and recording tool to study bird collisions with aerial cables. The BSI would be placed directly on

conductors (or guy wires on a communication tower) to detect strikes with wires and to distinguish bird strikes from other objects. The information, including impact, time, date, and conductor temperature would be transmitted to a ground station and retrievable via modem connection. This field-testing would occur simultaneously with on-the-ground searches to determine search bias.

3. The Bird Activity Monitor (BAM), which is an intelligent image-based sensing and recording tool to capture store, and transmit video images of bird incidents with utility structures (e.g., collision). The BAM could also be used to record bird flight activity around wind turbines and transmission lines, perching behavior on electricity poles, and bird responses to bird deterrent devices. To help ensure a successful outcome, a technical advisory group made up of project participants and potential stakeholders will review the technical performance objectives, designs, test plans, and results, and suggest improvements.
4. Line marking devices, sometimes know as Bird Flight Diverters (BFD), are readily available from a number of commercial sources. However, few, if any, have been scientifically evaluated to determine how well they work in the field. After the BSI and BAM have been completed and are available they will be used in the field to test the efficacy of existing and yet-to-be-designed BFDs at the site in North Dakota.

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

- Improving the reliability/quality of California's electricity by increasing power reliability and reducing outages caused by avian interactions with utility structures. This can reduce energy operation and maintenance (O&M) costs and improve the value of California's electricity.
- Improving environmental and public costs/risk from California's electricity system by developing devices to reduce avian fatalities from transmission and generation equipment. The monitors can also be used to test the efficacy of bird deterrent devices.

**Proposed Outcomes:**

1. Protocol for on-the-ground searches for bird carcasses will be fine tuned for the specific site to provide the best estimates for comparison ultimately with data provided from automated devices.
2. Determine areas with high collision risk. The development of affordable and reliable devices to determine areas with high collision risk will enable power producers to implement mitigation at the most appropriate locations. This will allow California to use and construct power generation and transmission facilities, while minimizing adverse avian impacts. It will also reduce the cost of monitoring avian interactions to determine potentially problematic lines or poles.
3. Reduce collisions and the incidence of temporary power outages. By employing these mitigation measures, power outages can be reduced and the reliability of the California electrical system can be increased. In addition, reducing maintenance and repair of costs will also reduce the cost of power production.
4. Help stakeholders comply with applicable laws. The state and federal Endangered Species Acts, the Bald Eagle Protection Act, and the Migratory Bird Treaty Act all protect birds that can potentially be affected by utility structures. These monitoring tools will help power producers implement effective mitigation measures and comply with these laws.
5. Better scientific data on utility effects on avian populations. Scientific evidence to determine how these bird interactions and fatalities affect avian populations is limited. Better data on the frequency of fatalities will provide insight into potential impacts on avian populations.

**Project Status:**

- Dead-bird searches have been conducted for two full field seasons, concluded in September 2002. These searches will not be conducted in 2003 in order that we may devote the maximum funding toward the hardware R&D effort. The data are being compiled, reduced, and evaluated, and will be discussed in a chapter in a forthcoming EPRI/CEC report titled *Bird Strike Indicator/Bird Activity Monitor and Field Assessments of Avian Mortality*.
- Design specifications for the bird strike indicator (BSI) were provided to EPRI by the contractor (EDM) in early 2002. Due to insufficient funding the hardware development lagged nearly five months. Since that time the components have been fabricated and bench tested. Limited field testing is being conducted by EDM during the winter of 2002-2003. During this period the components are being calibrated (for various bird strike intensities and cable dimensions) and evaluated for ruggedness and accuracy. A field demonstration is being scheduled for spring 2003.
- During 2002 the project developed the design specification for a bird activity monitor (BAM) and construction of a bench-scale prototype has begun. If continued funding is sufficient, field testing of the BAM will begin in fall of 2003 or spring 2004.
- Only small progress has been made on line-marking devices. The initial field deployment and testing of these devices will commence in 2004.
- In April 2003, EPRI published a CEC/EPRI progress report. Publication Number: 1005385. The report is on the CEC website:  
⇒ [www.energy.ca.gov/reports/2004-03-05\\_500-03-107F.PDF](http://www.energy.ca.gov/reports/2004-03-05_500-03-107F.PDF)

## **Protocol for the Intercomparison of Regional Climate Models for California**

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-023

**Contractor:** Lawrence Livermore National Laboratory

**Project Amount:** \$100,000

**Contractor Project Manager:** Phillip Duffy (925) 422-7322

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Completed

### **Project Description:**

Lawrence Livermore National Laboratory (LLNL) was tasked with the design of a protocol to inter-compare the simulation of California's climate using regional climate models. The actual implementation of this protocol, however, will be done under a separate research project.

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

- Improving the environment, public health, and safety of California's electricity by designing a protocol to inter-compare the simulation of California's climate using regional climate models.
- Improving the reliability, quality, and sufficiency of California's electricity by designing a protocol to inter-compare the simulation of California's climate using regional climate models.

### **Proposed Outcome:**

1. Develop a protocol with input from regional climate modelers from California and outside the State. The protocol will be a consensus document on how the modeling results should be compared with measurements to decide how the models perform and how to use the models in the future for the development of climate scenarios for California.

### **Actual Outcome:**

1. LLNL organized a meeting for experts to review a draft version of the protocol in June 2004. LLNL revised this protocol based on the input received from this group. The final protocol is now available as a PIER Report: Protocols for Projects for Simulation of Present and Future Climates in California. PIER Web Locaton:  
⇒ [www.energy.ca.gov/2005publications/CEC-500-2005-019/CEC-500-2005-019.PDF](http://www.energy.ca.gov/2005publications/CEC-500-2005-019/CEC-500-2005-019.PDF)

### **Project Status:**

The project was completed in the fall of 2004. The final report will be posted on the PIER website by April 2005.

**Rights-of Way Environmental Issues in Siting, Development, and Management (EPRI Program #57)**

**Contract #:** 500-02-028 **Project #:** 17

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

**Project Amount:** \$39,000

**Contractor Project Manager:** Richard Carlton (650) 855-2115

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

**Project Description:**

This project seeks solutions for meeting the economic and environmental challenges associated with siting, developing, managing, and upgrading transmission line, distribution line, and gas pipeline rights-of-way (ROWs). Issues addressed include use of herbicides, habitat fragmentation, integrated vegetation management practices within ROWs, and avian interactions with wind turbines and transmission lines.

Transmission and distribution corridors, gas pipelines, wind energy plants, and communications towers provide vital services to modern society. However, operating and expanding these critical infrastructures present growing economic and environmental challenges. Combining new science and innovative technology with state-of-the-art management practices is the only sure way to control costs and improve service reliability while protecting natural resources, enhancing environmental compliance, and addressing the concerns of the general public and other stakeholders.

Based on field and modeling studies, best-practices surveys, risk assessments, workshops, and technology development and demonstration activities, the program delivers tools, guidance, and information to help energy and other companies meet high-priority needs. These include increasing the cost-effectiveness of vegetation management practices while minimizing environmental impacts, identifying and reducing the risks to reliability posed by danger trees, maximizing the ecological and economic value of ROWs, minimizing negative interactions with birds, controlling facility development, upgrading costs while protecting natural resources, understanding and influencing public perceptions, and demonstrating environmental stewardship and corporate citizenship.

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

- Improving the environment, public health, and safety of California's electricity; and improving the reliability, quality and sufficiency of California's electricity by identifying strategies that promote statewide conservation opportunities within transmission line ROWs while maintaining system reliability and facilitating siting.

**Proposed Outcomes:**

1. Develop tools, guidance, and information to provide companies solutions that balance right-of-way issues regarding cost efficiency, vegetation management, habitat concerns, public perception, risks to reliability and environmental impacts.

**Actual Outcomes:**

1. Avian Interactions with Power Structures Wind Turbines and Communications Towers. Technical Report, *Bird and Bat Interactions with Wind Power Structures, Proceedings from a workshop in Jackson Hole, WY, Oct. 16-17, 2002*. EPRI Product ID# 101000. Delayed due to budget considerations. Projected completion date June 30, 2005.

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2. Avian Interactions with Power Structures Wind Turbines and Communication. Technical Report, *Tower Devices for Mitigating Avian Collision and Electrocutions*. Submitted Dec. 2004 to Tech. Publications. EPRI Product # 1005388.
3. Right of Way Vegetation Management. Technical Report, *Transforming Knowledge of Shrub Ecology and Management to Promote Integrated Vegetation Management on Power-Line Corridors*. Completed April 2004. EPRI Product #1008847.
4. Right of Way Vegetation Management. Technical Update 4 –Tech Issue, Utility Vegetation Management – *Use of Reliability Centered Maintenance Concepts to Improve Performance*. EPRI Product # 1008859.
5. Rights of Way Environmental and Land Use Issues. Technical Report, *Multiple Uses of Rights of Way*. Submitted to Technical Publications, Dec. 2004.
6. Rights of Way Environmental and Land Uses. Technical Report, *Environmental Risk Assessment of Chemical Encountered on Vegetation Management on Electric Utility Rights-of-Way*. Completed October 2004. EPRI Product # 1009445.
7. Airborne Inspection System. Technical Report, *Aerial Patrol of Rights-of-Way for Integrated Vegetation Management*. Completed November 2004. EPRI Product # 1005550.
8. Airborne Inspection System. Technical Report, *Electric Distribution Hazard Tree Risk Reduction Strategies*. Completed November 2004. EPRI Product # 1008480.

### **Project Status:**

The project was completed in December 2004.

The results of the project are being used by the Bonneville Power Administration, Western Power Administration, and other utility members.

## Utility/Power Producer Specific GHG Reporting Protocol

**Contract #:** 500-02-004 **Work Authorization #:** UC MR-015

**Contractor:** California Climate Action Registry

**Project Amount:** \$75,000

**Contractor Project Manager:** Jill Gravender (213) 891-6921

**Commission Contract Manager:** Gina Barkalow (916) 654-4057

**Status:** Completed

### **Project Description:**

The purpose of this project was to develop a utility- and power-producer-specific greenhouse gas (GHG) reporting protocol to supplement the Climate Change Action Registry's General Reporting Protocol (GRP).

The California Climate Action Registry (Registry) is a non-profit voluntary registry where companies and organizations with operations in the State can establish GHG emissions baselines, against which any future GHG emission reduction requirements may be applied. It encourages voluntary actions to increase energy efficiency and decrease GHG emissions. Using any year from 1990 forward as a base year, participants can record their GHG emissions inventory, and California will offer its best efforts to ensure that participants receive appropriate consideration for early actions in the event of any future state, federal, or international GHG regulations.

To enable registration, the Registry developed a GRP to give general guidance to emitters with respect to reporting GHG emissions in a consistent, credible, transparent manner. Registry participants—including businesses, non-profit organizations, municipalities, state agencies, and other entities—use the GRP, which provides solid guidance for general sources of GHG emissions, but cannot provide industry-specific guidance.

However, some industries have expressed a need for guidance more closely attuned to their industry, so the Registry has decided to develop industry-specific reporting protocols that facilitate reporting of complete, consistent, comparable, accurate and transparent data for key industries—the electricity generating sector among them. Approximately 16% of California's carbon dioxide emissions are from electric utilities and other power producers, and the electricity sector will continue to be a major source of greenhouse gas (GHG) emissions in the near future. Many of the State's large electric companies (i.e., PG&E, SMUD, and LADWP) are Registry participants, and industry-specific protocols will enable them to identify issues specific to the electricity sector.

Researchers identified current best practices in GHG emissions reporting and formed a utility/power producer working group to review and identify reporting issues. The working group helped the Registry to develop GHG emissions reporting recommendations for electric utilities and power producers.

### **The project supports the PIER Program objective of:**

- Providing cost-effective solutions for the environmental effects of energy production by the development of industry-specific reporting protocols for electric utilities and/or power generators. This will facilitate near-term reporting of GHG emissions, which in turn will help these large emitters to identify internal inefficiencies and needed improvements. Such improvements will help to increase energy efficiency, provide significant cost and energy savings, and help prevent the negative effects of climate change on California's resources and citizens.

**Proposed Outcome:**

1. Review and identify GHG reporting issues for electric utilities and other power producers and develop GHG emissions reporting recommendations for that sector.

**Actual Outcome:**

1. Successfully developed a draft and final protocol to support standardized and accurate entity-wide reporting of direct and indirect GHG emissions produced by the electric power and utility (natural gas, electricity transmission and distribution) sectors, to accompany the General Reporting and Certification Protocols.

**Project Status:**

The project was completed in 2004 and the final report will be available on the Commission web site by early 2005. The final Electric Power/ Electric & Natural Gas Utilities protocols are available at the California Climate Action Registry Web site:

⇒ [www.climateregistry.org/PROTOCOLS/Industry/](http://www.climateregistry.org/PROTOCOLS/Industry/)

## **ENV Projects Completed in 2003**

## Alternative Cooling Strategies

**Contract #:** 500-02-028 **Project #:** 4

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

**Project Amount:** \$20,670

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

### Project Description:

This project is designed to deliver scientific information, innovative technologies, and practical tools and guidelines for the use of water conserving cooling technologies and the use of non-freshwater sources of cooling water at industrial facilities. Project activities are designed to ultimately contribute to optimization of water use at power plants and other industrial facilities, while improving operating efficiency, reducing costs, enhancing compliance, and protecting aquatic resources. Project products are designed to help facility owners develop select appropriate cooling technology and water supplies while minimizing capital and operational costs. Current project work is increasingly critical as water resources become more constrained for power plant operations.

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

- Improving the reliability, quality, and sufficiency of California's electricity by delivering information designed to help facility owners develop effective compliance strategies to optimize water use at power plants and other industrial facilities.

### Proposed Outcome:

1. Evaluation of cost-effective cooling technologies and cooling water sources to minimize the electricity's sector effects on water supply.

### Actual Outcomes:

1. Technical Report, *Spray Cooling Enhancements of Air-Cooled Condensers*, EPRI Product #1005360.
2. Technical Report, *Use of Degraded Water Sources as Cooling Water in Power Plants*, EPRI Product #1005359.

### Status of Project:

The Project is complete. The Commission's participation in this project ended December 31, 2003.

## **Analysis of Aircraft Data from Plume Studies during 2000 Central California Ozone Study**

**Contract #:** 100-98-001 **Project #:** 40

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

**Subcontractors:** Tennessee Valley Authority : Atmospheric & Environmental Research, Inc.

**Project Amount:** \$140,000

**Contractor Project Manager:** Naresh Kumar (650) 855-2990

**Commission Contract Manager:** Marla Mueller (916) 503-1640

**Status:** Completed

### **Project Description:**

The purpose of this project is to analyze ozone production from power plant NO<sub>x</sub> emissions in California. Ground-level ozone (smog) is formed when volatile organic compounds (VOCs) present in ambient air react with NO<sub>x</sub>. Exposure to smog can cause or contribute to a number of respiratory problems. Because combined-cycle, gas-fired electric power plants emit NO<sub>x</sub>, it is important to measure the correlation between the amount of NO<sub>x</sub> emitted and the amount of ozone created, to determine the impact of power plants on ground-level ozone formation. Determining ozone potential efficiency (OPE), which is the amount of ozone formed per unit of NO<sub>x</sub> emitted, can help clarify the relationship between power plant emissions and ozone production.

PIERIA and EPRI are analyzing the Central California Ozone Study (CCOS) data collected from the Pittsburg and Moss Landing power plants and their plumes over the summer of 2000, to gain insight into the role that power plants play in contributing to California's ozone problem by estimating the ozone potential efficiency of the NO<sub>x</sub> emissions from both plants. The analysis of the extensive power plant plume data collected during the CCOS is important because it is the first data set to test the plume chemistry in the absence of significant amounts of sulfur oxides (SO<sub>x</sub>). The Pittsburg data allows researchers to analyze the chemical evolution of a power plant plume in a background dominated by the urban plumes from San Francisco and other nearby urban areas. The Moss Landing data allows researchers to analyze the chemical evolution of a power plant plume in a very clean marine environment.

Until this time, all of the work on ozone production from power plant NO<sub>x</sub> emissions has been conducted on the East Coast. This project represents the first comprehensive study of ozone production from power plants plumes in California. This West Coast effort is important because each region has its own distinct set of power plant fuels, geography, climate, and volatile organic compounds, all of which can play a role in ozone formation. The physical and chemical behavior of the plumes will be simulated using the model SCICHEM. A comparison of modeled and observed parameters will be used to improve model assumptions and algorithms.

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

- Providing environmentally sound electricity by establishing a quantitative association between power plant emissions and ozone production, which will help to develop environmentally sound regulations.

### **Proposed Outcome:**

Increased knowledge on the effects of power plant emissions on the formation of ozone. The determination of ozone potential efficiency and other parameters from the Moss Landing and Pittsburg power plants will significantly enhance understanding of the impact of power plant

plumes on ozone levels in California. It will also contribute to the future Energy Commission air quality modeling work to be conducted with ARB.

### **Actual Outcomes:**

In 2001 CCOS data were examined and rates of formation and removal of nitrogen oxide (NO<sub>x</sub>) species calculated, relative to the sum of all species. The data analysis suggests that under the conditions of the Moss Landing and Pittsburg plumes, the chain termination process overwhelmed the chain propagation process, leading to NO<sub>x</sub>-to-nitrate or nitric acid formation, but no net production of ozone in the plumes.

In 2002, EPRI contracted with Atmospheric & Environmental Research, Inc. (AER) to evaluate SCICHEM using the plume measurements from Moss Landing and Pittsburg power plants. The 3-dimensional model outputs were not available, so it was decided to run the 3-dimensional model using the inputs that were available from ARB. These included emissions inputs prepared by ARB and the meteorological input data files created using MM5 without using the four-dimensional data assimilation. According to Saffet Tanrikulu of ARB, 3-dimensional model performance using these inputs was poor. However, it was decided to use these inputs nevertheless because of unavailability of anything else.

The results from the SCICHEM evaluation with COCS 2000 aircraft plume measurement show that the model does not explain the observed plume data at downwind distances larger than 10 km. The model performance was better for the morning plume traverses than for the afternoon traverses. It is likely that the poor performance of the model is due to errors in the model inputs. The meteorological inputs used in this study are preliminary and are believed to have large uncertainties and errors. There were also interferences with urban plumes and mobile source NO<sub>x</sub> emissions during the afternoon traverses for both the Pittsburg and Moss Landing plumes that made it difficult to compare model results against the observation because SCICHEM only predicted the signature from the power plant plume.

Given the poor performance of the model using the currently available inputs, it will be useful to repeat this study when more accurate meteorological and emissions inputs are available later.

### **Project Status:**

The project is complete.

**Environmental Issues Management - Target 58**

**Contract #:** 500-00-023 **Project #:** 24

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

**Subcontractors:** Lang, Railsback & Associates : Alden Research Laboratory, Inc. : Heinz Center : Versar, Inc. : Oak Ridge National Laboratory

**Project Amount:** \$46,125

**Match Amount:** \$779,219

**Contractor Project Manager:** Doug Dixon (804) 642-1025

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

The purpose of this project is to provide practical information, guidance and tools for environmental analysis and operational decision making in support of Federal Energy Regulatory Commission (FERC) relicensing and environmental management at non-FERC-licensed hydropower projects. These products help hydropower operators effectively balance environmental protection and water resource demands with power generation.

For all hydropower operators, typical environmental issues include fish passage, in-stream flow restoration and protection, turbine entrainment and mortality, and water quality protection. Other issues relate to flood protection and water resource allocation for recreation, drinking water, and irrigation. Sediment management and proper decommissioning issues represent new challenges. This EPRI target offers cost-effective solutions to address critical hydro relicensing, environmental, and public interest issues through scientific and engineering expertise, forums for sharing information and lessons learned, and leveraged development of solutions to common problems.

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

- Improving the reliability/quality of California's electricity by compiling expert knowledge on the best practices for optimizing hydro plant operations and performance to enhance grid reliability.
- Improving the energy cost/value of California's electricity by helping to minimize the cost of hydropower while protecting the environment.
- Improving the environmental costs/risks of California's electricity by providing expert knowledge on addressing multi-stakeholder relicensing issues and by studying how best to manage entire watersheds containing hydroelectric development, rather than managing hydro projects individually.

**Proposed Outcomes:**

1. Provide information and tools for determining cost-effective passage and protection needs for migratory and non-migratory fish. EPRI provides a forum for exploring existing and emerging migratory and non-migratory fish issues, evaluating passage and protection technologies, and identifying research needs. Researchers are evaluating designs for more effective downstream passage facilities and approaches that mitigate turbine entrainment and spillway-related mortality.
2. Improve the ability to assess cumulative impacts and manage water resources for optimized power production while complying with environmental protection requirements.
3. Provide information and tools that improve project decommissioning and sediment management while addressing ecosystem protection and restoration concerns.

**Actual Outcomes:**

1. Fish Passage and Protection Management.
  - A report – *Evaluation of Angled Bar Racks and Louvers for Guiding Fish at Water Intakes* (1005193) – was published. The report presents information to support the evaluation of this fish protection technology for potential application at specific projects. The report also demonstrates how computational fluid dynamic modeling (CFD) can be used as a new tool to examine the local hydraulic performance of physical structures and how knowledge of local hydraulic conditions may affect fish avoidance response.
  - Proceedings were published from EPRI symposia on catadromous eels and sturgeon conducted in association with the American Fisheries Society at the AFS Annual Meeting in 2000. The peer-reviewed proceedings serve as a published record of papers presented at the symposia and were published in book form by the AFS.
  - A book – *Behavioral Technologies for Fish Protection at Water Intakes* (1006198) – was published by the American Fisheries Society with 100% EPRI support. The book contains 15 technical papers that review various behavioral technologies (e.g., light, sound, flow patterns) that may be used to guide fish away from water intakes.
  - Collaborative research with the U.S. Department of Energy, Hydropower Program and American Electric Power (AEP) was initiated to evaluate the effectiveness of artificial flow fields for guiding downstream migrating fish in hydroelectric forebays to bypasses (precluding turbine entrainment and mortality).
2. Water Resource Management.
  - An EPRI report – *Maintaining and Monitoring Dissolved Oxygen at Hydroelectric Projects* (1005194) – was published. This report provides a review of technologies and techniques for enhancing dissolved oxygen (DO) levels in reservoirs and releases from hydroelectric projects. The report also covers methods, equipment and techniques for monitoring DO levels.
3. Project Decommissioning and Sediment Management.
  - A report on the Heinz Center Study – *Dam Removal Decisions: Science and Decision Making* – was published by the Heinz Center. The report provides a framework and information sources for supporting project decommissioning and dam removal decisions. The current focus is on small, low-head, run-of-river dams. EPRI is supporting this collaborative effort of the Heinz Center, U.S. Bureau of Reclamation, and Federal Emergency Management Administration. A panel of experts from the funding organizations, academia, and non-governmental environmental organizations prepared the report.

**Project Status:**

This project has been completed.

## Evaluation of Design, Cost and Performance of Spray Enhancement of Dry Cooling

**Contract #:** 100-98-001 **Project #:** 43

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

**Project Amount:** \$285,000

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

### Project Description:

The purpose of this project is to evaluate the performance, costs, and potential problems associated with using spray enhancement for dry cooling in a pilot-scale evaluation at an existing dry cooled power plant.

Power plant dry cooling technologies significantly reduce a power plant's water demand. A 500-MW combined-cycle power plant using wet cooling technology requires, on average, 3 million gallons of water per day for cooling. The same power plant using dry cooling technology will require only about 5 percent (0.15 million gallons) per day of this total. The water savings, approximately 2.85 million gallons per day, could satisfy the water demands of more than 12, 445 people annually—nearly enough to supply the annual needs of Auburn, California.

Despite this enormous water saving, most power plants still use wet cooling. One reason for this is that dry cooling systems have traditionally prevented facilities from maintaining normal electricity output and peak efficiency during the hottest periods of the year, cutting into electricity production as a result of increased turbine back pressure. In California, this occurs at the same time that the State's electricity demand is the highest, which can affect electrical system reliability. One solution to this problem is to introduce a small amount of water spray into the inlet air stream to the cooling tower, where it evaporates and cools the air.

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

- Providing a reliable power supply by increasing the output of power generators using dry cooling systems. Enabling the delivery of more electricity to the grid increases the reliability of California's electrical system. Dry cooling systems can also enable power plants to be built closer to the end-users, regardless of the availability of fresh water supplies.
- Providing lower cost electricity by reducing the efficiency penalties associated with the use of dry cooling on very hot days.
- Providing environmentally sound electricity by reducing fresh water use considerably when dry cooling systems are used, leaving more fresh water for the environment and for delivery to customers.
- Providing safe electricity by helping to alleviate potential public health and safety issues. Successful use of dry cooling systems reduces potential surface and groundwater contamination, salt deposition from cooling tower drift, Legionnaires Disease, vapor emissions from volatile organic chemicals, and trihalomethane exposure.

### Proposed Outcomes:

1. Additional electricity delivered to the grid for summer 2001 and beyond. The enhanced spray configuration developed as part of this project should enable a dry cooling system

to operate more effectively. This program is currently adding extra electricity to prevent rolling blackouts during peak demand hours.

2. Produce additional electricity at power plants using dry cooling systems in the future. California has as much as 1,500 MW of installed capacity using air-cooled condensers and at least 500 MW out-of-state installed capacity that could benefit immediately from spray enhancement. This technology could help power plants increase output at existing plants by as much as 200 MW of peak capacity for summer 2002, and could also increase output at future power plants that use dry cooling.
3. Increased generation efficiency for dry-cooling systems could increase their use. The demonstrated performance and economic success of spray enhancement as a technique for reducing efficiency losses during hot weather may foster power producers' acceptance of dry cooling technology.

**Actual Outcomes:**

1. In 2001 researchers evaluated a spray enhancement system at the Crockett Cogeneration Facility—a 240-MW power plant in Crockett, California. The testing evaluated the capability of using low-pressure systems to reduce installation and operating costs of the systems. Results are described in a final report delivered to the Commission.
2. In 2002 researchers used information gathered during the Crockett project to develop detailed design and cost parameters that can be used to design and operate other spray enhancement facilities, and to identify other promising cooling configurations.

**Project Status:**

Commission participation in this project has been completed.

**Fish Protection Issues of the Clean Water Act Section 316(a) and (b) - Target 54**

**Contract #:** 500-00-023 **Project #:** 20

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

**Subcontractors:** Alden Research Laboratory, Inc. : Applied Biomathematics, Inc : Applied Science Associates : Argonne National Laboratory : Langhei Ecology LLC : Louisiana State University : Tetra Tech, Inc. : UT-Battelle LLC (Oak Ridge National Laboratory) : Webster Van Winkle

**Project Amount:** \$236,395

**Match Amount:** \$2,797,326

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

The purpose of this project is to support cost-effective fish protection and facility operational decision-making. The protection of single fish species and aquatic communities is a primary focus of water permitting for coal, oil, gas, and nuclear power plants and industrial facilities under Clean Water Act Section 316(a) (heated and chlorinated cooling water discharges), and Section 316(b) (entrainment into intakes and impingement on intake screens). This project provides methods for studying fish entrainment and impingement mortality and generating results for fish population predictions that will be used to address biological community and biodiversity risks associated with power plants and industrial facilities.

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

- Improving the environmental costs/risks of California's electricity by studying how to reduce the negative effects of thermal power plants (using once-through cooling) on aquatic resources in freshwater and marine environments.
- Improving the public health costs/risks of California's electricity by protecting fish in cost-effective ways to minimize environmental impacts on aquatic environments that impact humans.

**Proposed Outcomes:**

1. Produce a fish protection synthesis report that integrates all the information collected and developed in response to this issue for the purpose of regulatory development and implementation of those regulations.
2. Sponsor workshops and national conferences to explore technical issues related to Section 316(a) and (b) regulatory developments.
3. Provide guidance for the selection and application of aquatic ecosystem evaluation methods. Of particular importance is the utility of bioassessment criteria as screening tools for determining the potential for adverse environmental impacts for once-through cooling water operations.
4. Develop risk assessment tools applicable to Section 316(a) and (b) demonstrations, and endangered and threatened species issues.
5. Support research on technologies for protecting fish at water intakes.

**Actual Outcomes:**

1. 316(b) Fish Protection Synthesis Report.
  - A technical report – *Spawning and Nursery Habitat Assessment Methods* (1000732) – was published. This report covers methods available for identifying and assessing the

- quality of aquatic spawning and nursery habitat, and other sensitive areas, of relevance to cooling water intake systems (CWIS).
- An Internet resource was developed to provide current information on fish protection issues.
  - A quarterly technical newsletter (March, June, September and December) was published summarizing peer-reviewed technical publications of relevance to power plant impacts on fish populations.
2. Workshops/Conferences on Water Use Impacts on Aquatic Resources.
    - A customer workshop on ongoing projects was held in January 2001, providing detailed information on the progress of ongoing research and discussion of potential revision and new research needs.
    - A workshop for EPRI customers, EPA, and invited technical experts was held in January 2001 to share information on the EPA regulatory framework.
    - A symposium on *Defining and Assessing Adverse Environmental Impact under Section 316(b) of the Clean Water Act* was held in conjunction with the American Fisheries Society Annual Meeting, August 2001. Papers from this symposium were peer-reviewed and published both in electronic format and in a printed book.
  3. Aquatic Ecosystem Evaluation Methods.
    - A report – *Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact under Clean Water Act Section 316(b)* (1000731) – was published, providing an evaluation of EPA's proposal to use velocity as criteria for determining the potential for population impacts by assessing velocity into cooling water intake systems.
  4. Ecological Risk Assessment Frameworks.
    - A report – *Evaluating the Effects of Power Plants on Aquatic Communities: Guidelines for Selection of Assessment Methods* (1005176) – was published. The report provides guidelines for selecting methods to estimate effects of cooling water withdrawals on aquatic populations and communities.
    - A technical literature paper – *Compensatory Density Dependence in Fish Populations: Importance, Controversy, Understanding and Prognosis* – by Ken Rose and five other authors was published in the December 2001 issue of *Fish and Fisheries* (Volume 2, pages 293-327). This paper provides a comprehensive review on the state-of-knowledge relative to compensation or density-dependence theory.
    - A technical workshop was held November 15-16, 2001 at the decommissioned Connecticut Yankee plant to review a previous Connecticut River ecological study. The workshop examined the long-term impacts of the plant and the current status of fish populations in the river.
  5. Intake Technology Research.
    - EPRI initiated a project with collaborative water quality grant funding from the U.S. EPA that is investigating the efficacy of cylindrical wedge wire screens for fish protection at water intakes. Research will be concluded in December 2002.
    - A book – *Behavioral Technologies for Fish Protection at Water Intakes* (1006198) – was published by the American Fisheries Society with 100% EPRI support. The book contains 15 technical papers that review various behavioral technologies (e.g., light, sound, flow patterns) that may be used to guide fish away from water intakes.

**Project Status:**

This project has been completed.

**Global Climate Change: California Impacts**

**Contract #:** 500-97-043

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

**Subcontractors:** Charles River Associates : Stratus Consulting : Exponent Health Group

**Contract Amount:** \$2,159,800

**Match Amount:** \$40,100,672

**Contractor Project Manager:** Renee Guild (650) 855-8987

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Completed

**Project Description:**

The purpose of this project is to study the phenomenon of climate change, and from the understanding gained, provide the preliminary information necessary to evaluate the best options for addressing the impacts of climate change in the U.S., including a focus on California.

Climatic changes will likely alter the ecological characteristics of many ecosystems throughout our region. Such alterations could include increases in surface temperatures and changes in the form, timing, and intensity of precipitation. If temperature and precipitation regimes become modified, the economic costs to the state of California could be great. In recent decades for example, records show a trend toward earlier snowmelt in the principal water supply for the state, the snow pack of the Sierra Nevada. If this trend continues California will experience an increased danger of floods in the winter and possible exhaustion of the snowpack during spring or summer months. This would be problematic for California because it currently relies on the Sierra snowpack for about 50% of state annual runoff. Earlier snowmelt would impact state energy resources since approximately 20% of California's electricity comes from hydropower. Snowpack exhaustion might force electricity producers to switch to more costly forms of electricity generation during spring and summer months. While a changing climate would have effects on water resources throughout our region, change might also impact agricultural crop yields, coastal structures, and biodiversity unique to the Western United States.

PIER funding allows a more in-depth analysis in California than what would be gained by national studies alone. Specifically, this project will improve our understanding of the potential impacts on water resources, including hydropower generation, energy consumption, agriculture, and other areas affected by climate change. This project also identifies potential adaptation measures to address the expected climate impacts.

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

- Reducing environmental and public health costs/risk of California's electricity by conducting research to support California energy policy initiatives and further research related to global climate change.

**Proposed Outcomes:**

1. Develop broad-based climate scenarios for California to be used for impact and adaptation studies.
2. Assess the potential costs and implications of global climate change to California. The assessment will make extensive use of the existing framework and expertise developed by EPRI and its subcontractors for similar studies conducted at the national and international levels.

The final report will include the following information and analyses:

1. Detailed climatic scenarios.
2. Estimated changes in vegetation patterns.
3. Evaluation of health effects due to changes in weather conditions.
4. Preliminary estimation of changes in energy consumption due to a warmer climate.
5. Preliminary evaluation of impacts on water resources and hydropower production in particular.
6. Preliminary evaluation of impacts on agriculture, timber production, coastal structures, and an example ecosystem (coastal sage scrub).

**Actual Outcomes:**

The final report contains all the products listed above. The Commission Contract Manager formed an external review team composed of representatives from different state agencies to assist in the review of the different products. The results of this project suggest that climate change would be costly for California and would severely affect the State's natural systems. The researchers presented the final results of this preliminary study at a conference held in February 2003. The California Department of Water Resources used results of this study to inform the preparation of the 2003 State Water Plan.

**Project Status:**

The project ended on March 31, 2003.

## Greenhouse Gas Emission and Metrics

**Contract #:** 500-00-021

**Contractor:** Lawrence Berkeley National Laboratory

**Contract Amount:** \$228,000

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

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Completed

### Project Description:

The purpose of this project is to fulfill the mandate(s) in Senate Bill (SB) 1771 and its subsequent amendments that require the California Energy Commission to provide technical assistance to the California Climate Action Registry. This registry, created by the same Senate Bill, allows California entities to register their annual greenhouse gas (GHG) emissions. The Commission contracted with Lawrence Berkeley National Laboratory (LBNL) to generate research products that the Commission needs for the preparation of technical recommendations to the Registry.

LBNL has developed GHG emission allocation rules to estimate indirect carbon dioxide (CO<sub>2</sub>) emissions associated with the actual consumption of electricity. The goal is to create and test a set of methods that fairly allocate emissions, taking into account the amount and time of consumption and resource mixes of electricity providers. The methodology will distinguish between in-state and out-of-state electricity generation.

The project will also develop metrics and conduct case studies of three California companies to examine the effectiveness of the metrics. These metrics could be used to compare emission trends between similar companies and to estimate the emissions that would have occurred if the companies did not implement measures to reduce their GHG emissions.

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

- Improving the environment and public health costs/risks by providing the methods needed to allocate CO<sub>2</sub> emissions from electricity consumption and metrics to track progress in reducing GHG emissions.

### Proposed Outcomes:

This project will create multiple benefits for regulators, GHG producers, and Californians by:

1. Encouraging participation in the Registry. Standard and clear methodologies will encourage the participation of California entities in this voluntary program.
2. Provide real world experience with the use of metrics in the state before the Registry allows companies to use metrics to track and report emissions.

### Actual Outcomes:

LBNL has developed a method to estimate indirect carbon dioxide emissions from electricity consumption. LBNL participated at a conference organized by the Registry where they presented the metrics and major findings from their case studies. A significant outcome of this conference is that stakeholders now believe that the use of the metrics will allow them to accurately report greenhouse gas emission trends while protecting their confidential information. The case studies suggest that participants in the Registry should collect more than basic energy consumption data to allow the proper use of metrics.

### Project Status:

This project ended in December 2003.

## Hydropower Environmental Issues

**Contract #:** 500-02-028 **Project #:** 6

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

**Project Amount:** \$38,000

**Contractor Project Manager:** Doug Dixon (804) 642-1025

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

### Project Description:

The purpose of this project is to deliver up-to-date information, effective tools, and practical guidance for assessing and minimizing environmental impacts and balancing often-conflicting stakeholder demands while maximizing hydropower generation. Project activities provide information, guidance, and tools for environmental analysis and operational decision-making in response to regulatory requirements and policy initiatives concerning fish passage (upstream and downstream), in-stream flow restoration and protection, turbine entrainment and mortality, water quality, sediment management, and project decommissioning. All work addresses issues regarding maintaining and improving water availability and quality, maintaining and strengthening portfolios of generation options, and managing ecological assets. This project provides scientific information to support hydropower operations, permitting, and re-licensing decisions.

This project supports the PIER goal of improving the environmental and public health cost/risks of California's electricity by providing science-based assessments and information to assist development of balanced strategies for hydropower generation and the management and protection of aquatic resources.

### Proposed Outcome:

1. Research conducted under this project provided facility owners and other stakeholders with tools and methodologies for meeting the demands of existing and new environmental requirements through helping to minimize negative effects on aquatic resources while helping to sustain hydropower operation.

### Actual Outcomes:

1. A draft of the report, *Demonstration Flow Assessment: Procedures for Judgment-Based In-Stream Flow Studies*, EPRI Product ID# 1005389.
2. Supported Annual AFS-EPRI Symposium on Fish Passage and Protection Issues, August 10 – 14, 2003, Quebec City, EPRI Product ID# E207979.
3. EPRI Technical Newsletter on Water Resource Management, issued March, June and September 2003, EPRI Product ID# E208105.

### Project Status:

The Commission's participation in this project ended December 31, 2003.

## Rights of Way Environmental Issues in Siting, Development and Management

**Contract #:** 500-02-028 **Project #:** 5

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

**Project Amount:** \$69,000

**Contractor Project Manager:** Robert Goldstein (650) 855-2593

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

### Project Description:

This project seeks solutions for meeting the economic and environmental challenges associated with siting, developing, managing, and upgrading transmission line, distribution line, and gas pipeline rights-of-way (ROWs). Issues addressed include use of herbicides, habitat fragmentation, integrated vegetation management practices within ROWs, and avian interactions with wind turbines and transmission lines.

Transmission and distribution corridors, gas pipelines, wind energy plants, and communications towers provide vital services to modern society. However, operating and expanding these critical infrastructures present growing economic and environmental challenges. Combining new science and innovative technology with state-of-the-art management practices is the only sure way to control costs and improve service reliability while protecting natural resources, enhancing environmental compliance, and addressing the concerns of the general public and other stakeholders.

Based on field and modeling studies, best-practices surveys, risk assessments, workshops, and technology development and demonstration activities, the program delivers tools, guidance, and information to help energy and other companies meet high-priority needs. These include increasing the cost-effectiveness of vegetation management practices while minimizing environmental impacts, identifying and reducing the risks to reliability posed by danger trees, maximizing the ecological and economic value of ROWs, minimizing negative interactions with birds, controlling facility development, and upgrading costs while protecting natural resources, understanding and influencing public perceptions, and demonstrating environmental stewardship and corporate citizenship.

This project supports the PIER Program objectives of improving the environment, public health, and safety and of improving electricity reliability, quality and sufficiency by identifying strategies that promote statewide conservation opportunities within transmission line ROWs while maintaining system reliability and facilitate siting.

### Proposed Outcomes:

Tools, guidance, and information to assist companies solutions that balance right-of-way issues regarding cost efficiency, vegetation management, habitat concerns, public perception, risks to reliability and environmental impacts.

### Actual Outcomes:

1. Technical Report, Human Risk Assessment of Chemicals Encountered in Vegetation Management on Electric Utility Rights-of-Way. EPRI Product ID#1005367.
2. Technical Report, Transmission Lines and Property Values: State of the Science, EPRI Product ID# 1005546.
3. Technical Report, *Landscape Fragmentation and Electric Transmission Corridor Siting and Management*, EPRI Product ID#1005371.

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4. Technical Report, *Integrated Power Line and Rights-of-Way (ROQ) Management Using the Airborne Inspection System (AIS 2.0)*, EPRI Product ID# 1005549.
5. Technical Report, *Survey of Electric and Gas Rights-of-Way Practitioners: Current Practices and Views of the Future*, EPRI Product ID# 1009291.
6. Technical Report, *Bat Interactions with Wind Turbines at the Buffalo Ridge, Minnesota Wind Resource Area*, EPRI Product ID# 1009178.
7. Technical Report, *Bird Strike Indicator/Bird Activity Monitor and Field Assessment of Avian Fatalities*, ERPI Product #1005385.
8. The 6th World Conference on Birds of Prey and Owls, held in Budapest, Hungary, May 18–23, 2003. The conference, cosponsored by EPRI, provided comprehensive ecological information on vultures, falcons, eagles, and owls and their environments. EPRI organized and chaired a special session on raptor electrocutions.

### **Project Status:**

The project has been completed. The Commission's participation in this project ended on December 31, 2003.

**Section 316(a) and (b) Fish Protection Issues**

**Contract #:** 500-02-028 **Project #:** 3

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

**Project Amount:** \$215,400

**Contractor Project Manager:** Doug Dixon (804) 642-1025

**Commission Contract Manager:** Joe O’Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

This project supports the PIER goal of improving the environmental and public health cost/risks of California’s electricity by providing science-based assessments and information to assist development of balanced strategies for hydropower generation and the management and protection of aquatic resources.

**Proposed Outcome:**

1. Research conducted under this project addressed information gaps in our understanding of the effects of cooling water intake structures on coastal ecosystems as well as providing power plant operators and other stakeholders with the tools and methodologies for assessing and minimizing the negative effects of such structures as well as for meeting the demands of regulatory new mandates.

**Actual Outcomes:**

1. Technical report, *Evaluating the Effects of Power Plant Operations on Aquatic Communities*, EPRI Product ID# 1007821.
2. Technical report, *Enhancement Strategies for Mitigating Potential Operational Impacts of Cooling Water Intake Structures: Approaches for Enhancing Environmental Resources*, EPRI Product ID#1007454.
3. Technical report, *Laboratory Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intakes*, EPRI ID# 1005339.
4. Technical report, *Impacts of Volumetric Flow Rate of Water Intakes on Fish Populations and Communities*, EPRI ID#1005178 - 3/25/2003.
5. Workshop, July 7, 2003, *Power Generation Impacts on Aquatic Resources*, EPRI Product ID#E207967.

**Current Status:**

The project has been completed.

## Technology Assessment of Electrotechnologies

**Contract #:** 100-98-001 **Project #:** 42

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

**Subcontractors:** Global Energy Partners, LLC

**Project Amount:** \$220,000

**Match Amount:** \$110,000

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

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

### Project Description:

The purpose of this project is to assess various environmental electrotechnologies under development, assess their commercialization potential and possible impact on California's economy, and recommend a selected number of technologies worthy of further funding by the California Energy Commission.

Some electrotechnologies, such as reverse osmosis and ozonation, are well established and commercially available. Others, such as radiofrequency (RF) drying and electron beam irradiation, are less mature and further development is necessary to bring these technologies to market. As environmental regulations tighten in response to public health and ecosystem concerns, industries must seek improved methods to control or remediate pollution. In order to more effectively appropriate resources to the most promising and applicable emerging technologies, it is important to develop a good understanding of the potential performance and cost of electrotechnologies designed for environmental protection.

To facilitate the use of effective electrotechnologies, PIEREA and EPRI assessed a variety of technologies under development in the United States, specifically focusing on those that show particular promise for use in California. The resulting report describes the technical and economic status of these emerging electrotechnologies, offers projections of their future performance and costs, and recommends those technologies appropriate for receiving any developmental funding provided by the CEC.

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

- Providing environmentally sound electricity by expanding the use of electrotechnologies that can be used for environmental control in a variety of industrial processes. Their expanded use can potentially reduce the waste stream from power plants (as well as other industrial facilities).
- Supporting the development of new electricity applications to solve environmental issues by using the evaluation of the efficacy of electrotechnologies to help industries mitigate their impacts on the environment.

### Proposed Outcomes:

1. Increase the use of beneficial electrotechnologies in California. This assessment will enable the Energy Commission to effectively target future research into improving the economic and public benefits of environmental electrotechnologies.
2. Promote improved treatment of industrial emissions. Electrotechnologies can replace treatments using potentially harmful chemicals, reducing the amount of chemicals released by industrial facilities, including power plants.

**Actual Outcomes:**

The contractor developed a list of approximately 45 promising electrotechnologies along with a set of criteria to quantitatively rank them. Detailed evaluations of the technologies, research needs, and projected costs were developed for the most promising technologies. Based upon this evaluation, the contractor identified eight emerging technologies that were felt to be very promising for future support.

**Project Status:**

The final report (publication number 500-03-068C) on the results of this work has been completed and is available on the Energy Commission website.

## **ENV Projects Completed in 2002**

**Degraded or Reclaimed Power Plant Cooling Water - TC Target 105**

**Contract #:** 100-98-001 **Project #:** 53

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

**Project Amount:** \$77,987

**Match Amount:** \$77,987

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O’Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

The purpose of this project is to identify the availability of degraded water that electricity producers can use to reduce the demand for cooling water from local water supplies. Thermal power plants are cooled by transferring the heat produced by electricity generation to a body of water or the atmosphere. The most common cooling method is to use evaporative cooling towers, which use significant quantities of water. In California (and throughout the world), environmental health and safety concerns, aesthetic issues, and competing demands for fresh water have forced thermal power plants to consider alternative cooling water supplies.

By better understanding the economics and environmental impacts of using unprocessed, degraded cooling water and by identifying the availability of degraded or reclaimed cooling water supplies, electricity producers can expand their use of alternative water sources and reduce the demand from local water supplies. In fact, the Energy Commission estimates that if all of the power plants currently projected to be built in California used degraded water for cooling, approximately 140,000 acre-feet per year of freshwater could be diverted to other uses. This equals the annual water use of 545,000 Californians—more than enough water to supply the cities of Fresno and Thousand Oaks combined.

In this project, PIEREA and EPRI are working to identify research that could define and improve the relative costs and environmental impacts of the use of untreated, degraded, or reclaimed water. Researchers are seeking to:

1. Identify potential types of degraded water, the pollutants specific to these types of water, and the water quality requirements necessary for cooling water.
2. Investigate the technical feasibility of using degraded or reclaimed water for power plant cooling.
3. Identify commercial and emerging treatment technologies to treat degraded or reclaimed water.

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

- Providing environmentally sound electricity by helping power producers mitigate the environmental impacts of generating California's electricity by decreasing the amount of fresh water needed for power plant cooling.
- Providing safe electricity by improving public health and safety by reducing potential surface and groundwater contamination, salt deposition from drift, Legionnaires Disease, vapor emissions from volatile organic chemicals, and trihalomethane exposure.
- Providing reliable and affordable electricity by improving the reliability and cost-effectiveness of California's electricity system. Utilizing alternative water supplies will enable power plants to be built closer to end-users, regardless of fresh water availability.

**Proposed Outcomes:**

1. More fresh water will become available for uses other than industrial cooling. It will be possible for more power plants to be built to supply California's growing electricity needs, without compromising the water supply of the communities or the environment in which they are sited. Approximately 140,000 acre-feet per year (125 million gallons per day) of freshwater could be diverted to other uses.
2. Power plants and other industrial facilities that need water for cooling can be sited in more diverse locations. These facilities could be sited where the need is great, but freshwater is unavailable, thereby helping to strengthen the state's electricity reliability.

**Actual Outcomes:**

Researchers conducted the following activities to enable industry and regulatory agencies to better evaluate the factors involved in using untreated, degraded, or reclaimed water for industrial cooling:

1. Developed a Source Water Evaluation Methodology to help power producers assess degraded and freshwater sources for cooling tower make-up.
2. Evaluated the technical feasibility and economics of using degraded water for cooling towers.
3. Developed three case studies of power plants that use degraded water for cooling, using the Source Water Evaluation Methodology. Researchers compared the case study examples with freshwater cooling examples and benchmarked costs.
4. Identified the environmental, health, and occupational safety impacts associated with degraded water in wet cooling towers and evaluated all streams leaving the cooling system.
5. Identified commercial pre-treatment, side-stream, and post-treatment technologies available for using degraded water for power plant cooling.
6. Identified new or emerging treatment technologies and processes for using degraded and reclaimed water.

**Project Status:**

A report describing the results of this work was delivered in 2002. The project has been completed.

**Facilities Water Management - Program 56**

**Contract #:** 500-00-023 **Project #:** 57

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

**Subcontractors:** John S. Maulbetsch : University of Southern California : Waters Edge Technology LLC

**Project Amount:** \$62,196

**Match Amount:** \$739,914

**Contractor Project Manager:** Rick Carlton (650) 855-2115

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

The purpose of this project is to develop and implement cost-effective strategies for controlling biofouling, treating wastewater, and treating and recycling cooling water while maintaining minimal impact on the environment. This EPRI target will focus on strategies that include reducing biocide discharges, removing heavy metals, minimizing nitrogen compounds to reduce eutrophication (an aquatic environment wherein plant life is favored over animal life) of water resources, and reducing bioaccumulative pollutants from plant wastewater. For example, EPRI has demonstrated the use of constructed wetlands for treatment of point- and non-point source aqueous discharges.

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

- Improving the energy cost/value of California's electricity by developing cost-effective alternative water sources and alternative technologies/methods of treatment of these alternative water sources. The purposes of these alternatives are to minimize environmental impact at reduced costs for treatment of cooling water and increased water recycling/reuse, while improving plant performance and preventing corrosion damage.
- Improving the environmental and public health costs/risks of California's electricity by providing solutions that reduce or eliminate the water-related impacts of electricity generation in California.

**Proposed Outcomes:**

1. Develop information and methods for designing constructed wetlands as a low-cost alternative for meeting water quality standards.
2. Prepare guidelines for the use and optimization of alternative cooling strategies that will provide options to participants in meeting water use requirements of operating permits.
3. Provide nontoxic options for biofouling control that will maintain or improve thermal performance and reduce corrosion in cooling and service water systems.

**Actual Outcomes:**

1. A manual for the *Design, Construction, and Maintenance for Passive Treatment of Wastewaters* (1005352) was published. The manual describes design approaches for specific contaminants that will allow environmental managers to design and implement passive systems using internal staff in cases in which this technology is readily applicable.
2. A desk-top planning tool, *PT2 Version 1.0*, was developed in support of, and is included in *Design, Construction, and Maintenance for Passive Treatment of Wastewaters* (1005352) to allow rapid evaluation of conceptual passive system designs, construction requirements, and cost estimates.
3. The report, *Dry and Wet/Dry Cooling for Power Generation* (1005358) was published.

**Project Status:**

The project has been completed.

## **Golden Eagles in a Perilous Landscape: Predicting the Effects of Mitigation for Wind Turbine Blade-Strike Mortality**

**Contract #:** 500-97-036

**Contractor:** University of California, Santa Cruz

**Subcontractors:** H. Peters Consulting

**Contract Amount:** \$675,121

**Contractor Project Manager:** Grainger Hunt (530) 336-7281

**Commission Contract Manager:** Dick Anderson (805) 821-3715

**Status:** Completed

### **Project Description:**

The purpose of this project was to assist in understanding the complex interactions of golden eagles with the electrical power produced by the Altamont Pass Wind Resource Area (APWRA) structures. In the APWRA, an estimated 40-60 golden eagles and several hundred red-tailed hawks are killed annually by collisions with wind turbines. Electrocution is another source of golden eagle fatality, both within and outside the APWRA. These fatalities are a concern for stakeholders and produce costly permitting delays.

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

- Improving the environmental costs/risks of California's electricity by providing critical information to help reduce golden eagle fatalities in the APWRA.
- Improving the reliability/quality of California's electricity by providing information to overcome regulatory barriers to siting or replacing wind turbines.

### **Proposed Outcomes:**

1. Provide information on whether the APWRA-wide golden eagle population is stable, or increasing or declining.
2. Determine whether there is a correlation between golden eagle use of the APWRA and ground squirrel concentrations.
3. Determine whether ground squirrel concentrations are attracting golden eagles into risky situations.
4. Document golden eagle use of the following areas:
  - Where recent structural modifications have been made.
  - Where wind turbines in high-risk areas have been removed (determined by incidental carcass discoveries).
  - Where there has been repowering of some areas with new, larger, more efficient wind turbines.
5. Improve public perception of wind power because the net result of the industry's efforts to mitigate this issue can be directly measured.

### **Actual Outcomes:**

The project is complete and a final report is published (Publication number P500-02-043F) and available. Highlights of the final report include:

1. Out of 100 golden eagle fatalities, at least 54% were attributed to electrical generation.
2. 42 % from wind turbine strikes and 12% from electrocution.
3. Fatalities were greatest for subadults (ages 1-3 years) and non-breeding adults (floaters 4+ years). The territories of breeding adults were mostly outside of the APWRA and the hunting behavior of juveniles (< 1 year) make them less vulnerable to blade strikes.

4. The golden eagle population appears stable, as there was no annual rate of population decline.
5. Any further decrease in survival or reproduction would result in a population decline.
6. A stable contingent of floaters is necessary to buffer the population against decline. The population showed no production of a floater buffer, but no paucity of floaters.
7. The population may currently be dependent on an immigrant source of floaters.
8. Circumstantial evidence suggests Type 13 (Kenetech 56-100) turbines or conditions in the area of Type 13 turbines were more hazardous to eagles than conditions in the area containing other types of turbines.
9. It was surmised that the short distance between turbines and short distance between the turbine blade and the ground created hazardous conditions for eagles trying to pass between or under Type 13 turbines.
10. Repowering did not occur during the study period. This suggests that the new, larger turbines with greater distances between both blade tips and ground may be less hazardous to eagles.
11. Eagles tended to concentrate in areas of high ground squirrel density, their principal prey. Therefore, ground squirrel control may reduce eagle use of particular areas. However, other negative consequences are associated with ground squirrel control.
12. Increasing land use development around the APWRA is reducing habitat and prey abundance for eagles.

**Project Status:**

The project has been completed.

## Hydropower Relicensing Environmental Issues - Program 58

**Contract #:** 500-00-023 **Project #:** 59

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

**Subcontractors:** Lang, Railsback & Associates : Alden Research Laboratory, Inc. : Heinz Center : Versar, Inc. : Oak Ridge National Laboratory

**Project Amount:** \$46,125

**Match Amount:** \$449,928

**Contractor Project Manager:** Doug Dixon (804) 642-1025

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

### Project Description:

This program provides practical information, guidance and tools for environmental analysis and operational decision making in support of Federal Energy Regulatory Commission (FERC) relicensing and environmental management at non-FERC-licensed hydropower projects. These products help hydropower operators effectively balance environmental protection and water resource demands with power generation.

For all hydropower operators, typical environmental issues include fish passage, in-stream flow restoration and protection, turbine entrainment and mortality, and water quality protection. Other issues relate to flood protection and water resource allocation for recreation, drinking water, and irrigation. Sediment management and proper decommissioning issues represent new challenges. This EPRI target offers cost-effective solutions to address critical hydro relicensing, environmental, and public interest issues through scientific and engineering expertise, forums for sharing information and lessons learned, and leveraged development of solutions to common problems.

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

- Improving the reliability/quality of California's electricity by compiling expert knowledge on the best practices for optimizing hydro plant operations and performance to enhance grid reliability.
- Improving the energy cost/value of California's electricity by helping to minimize the cost of hydropower while protecting the environment.
- Improving the environmental costs/risks of California's electricity by providing expert knowledge on addressing multi-stakeholder re-licensing issues and by studying how best to manage entire watersheds containing hydroelectric development, rather than managing hydro projects individually.

### Proposed Outcomes:

1. Develop a methodology for determining instream flow needs via a professional judgment (qualitative) approach.
2. Provide information and tools for determining cost-effective passage and protection needs for migratory and non-migratory fish.
3. Improve the ability to assess cumulative impacts and manage water resources for optimized power production while complying with environmental protection requirements.
4. Provide information and tools that improve project decommissioning and sediment management while addressing ecosystem protection and restoration concerns.
5. Complete a Tailored Collaboration entitled "Sedimentation Issues at California Hydro Facilities."

**Actual Outcomes:**

1. Instream Flow Management.
  - Technical efforts are progressing on developing the qualitative instream flow prediction approach. A final report will be available by December 31, 2003.
2. Fish Passage and Protection Management.
  - In 2002 EPRI began development of a desk reference on technologies and approaches for upstream and downstream fish passage. The Fish Passage Manual will be developed in a loose-leaf binder format to facilitate future insertion of revised chapters as the state of the art in fish passage technology advances. Initial 2002 efforts focused on development of the manual framework, a literature review, and collection of other information on fish passage. Progress on the manual is summarized in an informal technical update report, *Upstream and Downstream Fish Passage and Protection Technologies for Hydroelectric Application: A Fish Passage and Protection Manual* (1005392). Efforts in 2003 will focus on completing the manual.
  - Researchers examined the influence of fluid dynamics on fish behavior, including role of (1) riverine turbulence in the migratory paths selected by downstream-migrating fish, and (2) fluid flows near and in turbines that result in fish injury and mortality. Researchers also examined how computational fluid dynamic (CFD) modeling can simulate the functional attributes of fluid flows important to fish movements and damage. Research results may lead to improvements in active and passive technologies for guiding organisms toward bypasses or away from hazards such as spillways and turbine intakes. A technical update report presenting the results – *Application of Eco-Hydraulic Principles to Fish Passage/Protection* (1005391) – was prepared and submitted for publication. Research on this issue will continue into 2003.
3. Water Resource Management.
  - An EPRI report – *Maintaining and Monitoring Dissolved Oxygen at Hydroelectric Projects: Status Report* (1005194) – was published in May 2002. The report provides hydropower operators with state-of-the-art information on methods and technologies for mitigating dissolved oxygen (DO) issues in hydro project reservoirs and tailwaters.
4. Sediment and Project Decommissioning Management.
  - A report on the Heinz Center Study – *Dam Removal Decisions: Science and Decision Making* – was published by the Heinz Center in May 2002. The report provides a framework and information sources for supporting project decommissioning and dam removal decisions. The current focus is on small, low-head, run-of-river dams. EPRI supported this collaborative effort of the Heinz Center, U.S. Bureau of Reclamation, and Federal Emergency Management Administration. A panel of experts from the funding organizations, academia, and non-governmental environmental organizations prepared the report. Copies of this report (1005396) can be obtained from the EPRI Distribution Center.
5. Tailored Collaboration – Sedimentation Issues at California Hydro Facilities.
  - PIEREA and EPRI examined and characterized sediment issues at hydropower facilities in California, reviewed environmentally responsible remedial strategies, developed a framework for sediment management guidelines, and prepared a final report describing project findings. The draft final report from this effort was delivered to CEC for review in early 2002. Because of the low response rate to the EPRI survey, CEC decided not to finalize the report. EPRI is currently investigating the feasibility of increasing the response rate via an informal phone survey of

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California hydroelectric operators. This phone survey is being conducted via EPRI base funds.

**Project Status:**

This project has been completed.

**Mercury, Metals and Organics in Aquatic Environments - Program 53**

**Contract #:** 500-00-023 **Project #:** 54

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

**Subcontractors:** Battelle Memorial Institute : Dr. Stephen J. Klaine : Clemson University : Fresh Water Institute : Great Lakes Environmental Center : K.S. Crump Group : Tetra Tech, Inc. : University of Wisconsin Systems : Water Environment Research Foundation

**Project Amount:** \$103,525

**Match Amount:** \$1,134,111

**Contractor Project Manager:** John Goodrich-Mahoney (202) 293-7516

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Completed

**Project Description:**

The purpose of this project is to provide the CEC with information and tools to help improve the scientific basis for California water quality criteria. The products of this program may also facilitate the use of site-specific conditions and new data to assess the impacts of toxic chemicals in California's aquatic environments. Findings can be applied directly to meet specific technical challenges. They are also useful to the regulatory and scientific communities, helping to inform ongoing deliberations and to increase understanding of critical issues.

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

- Improving the environmental and public health costs/risks of California's electricity by providing tools that lead to more precise estimates of human health and ecological risks and establish the basis for more cost-effective regulations and compliance methods.

**Proposed Outcomes:**

1. Enhance the Dynamic Mercury Cycling Model—which predicts ecosystem responses to changing mercury loadings—and conduct field research into processes that affect mercury fluxes and bioavailability in aquatic ecosystems.
2. Conduct research to support improvements to the process by which EPA establishes national ambient aquatic life criteria and the development of models for assessing metal toxicity on a site-specific basis.
3. Apply new and updated information on arsenic health effects to address specific issues related to reducing uncertainties in the cancer health risk assessment for arsenic in water, and reduce reliance on conservative default assumptions in human health risk estimates for arsenic.
4. Provide an assessment of the biological criteria development process as it may affect industry along large rivers.

**Actual Outcomes:**

1. Dynamic Mercury Cycling Model.
  - EPRI developed and released Version 2.0 of the Dynamic Mercury Cycling Model. Version 2 allows estimation of mercury speciation, pool sizes, fluxes, transformations and fish tissue concentrations. This enhanced software enables users to analyze "what if" scenarios based on changing environmental conditions or mercury loading rates.
  - A peer-reviewed paper, "Differences in Reactivity and Mobility Between New and Old Mercury Deposition in a Boreal Ecosystem," was submitted to *Environmental Science and Technology*.

2. Aquatic Life Criteria.
  - A technical report, *Characterizing the Risk Associated With Episodic Exposure of Metals in Effluents: Influence of Episodic Copper Exposure on Daphnia magna* (1005319), was published. The report describes EPRI research on fluctuating exposures in aquatic systems and the prediction of acute and chronic lethal effects. Results of this research were also presented at the recent Society of Environmental Toxicology and Chemistry annual meeting in Salt Lake City.
  - A peer-reviewed paper, "Population Response of *Daphnia magna* to Copper Exposure Over Multiple Generations," (E207963) was submitted to *Environmental Toxicology and Chemistry* in January for publication.
3. Health Risks from Arsenic.
  - Researchers integrated existing and recent data on arsenic's biological mode of action and toxicokinetics, focusing on the pharmacokinetic model for arsenic. Results were presented at the Fifth International Conference on Arsenic Exposure and Health Effects. EPRI cosponsored the conference, which was held in San Diego in July 2002. Research results will also be delivered as peer literature, "Advancement Toward a Biologically Realistic Cancer Risk Assessment for Inorganic Arsenic," (E207964), which will be published in the conference proceedings.
4. Biological Criteria Assessment.
  - A technical report, *Fish Sampling in Large Freshwater Rivers: A Review of the Methods* (1005322) was published. The document reviews guidance from a total of 29 reports regarding fish sampling protocols for large freshwater rivers. It also discusses how biocriteria might be applicable to the assessment of fish communities in large rivers and includes recommendations on future research.

**Project Status:**

This project has been completed.

**Rights-of-Way Environmental Issues in Siting, Development and Management - Program 57**

**Contract #:** 500-00-023 **Project #:** 58

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

**Subcontractors:** EPRI Solutions : Resource Strategies, Inc. : URS Greiner Woodward Clyde : EDM International, Inc. : Syracuse University

**Project Amount:** \$49,200

**Match Amount:** \$641,459

**Contractor Project Manager:** John Goodrich-Mahoney (202) 293-7516

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Completed

**Project Description:**

This program's tools and information support rights-of-way (ROW) practices that protect the environment while controlling costs associated with ROW siting, development, and management. Environmental issues confronting ROW owners and users include avian interactions (bird collisions, nesting and perching) with power and communications structures environmental impacts of access roads, biodiversity and habitat fragmentation. Concurrently, ROW siting, development, and management are increasingly guided by government policies and regulations. Competitive markets demand reliable, high-quality electrical service while compelling companies to be ever mindful of capital and operational budgets. Dealing with these challenges requires balancing cost-effectiveness with compliance, environmental stewardship, and responsiveness to the public. This program develops and delivers scientific information and innovative approaches to help ROW owners/users contain costs while responding to the competitive marketplace and practicing environmental stewardship.

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

- Improving the environmental costs/risks of California's electricity by providing information and methods that enable companies, regulators, and stakeholders to assess, minimize, and mitigate environmental impacts associated with rights of way and to implement cost-effective ROW management strategies.
- Improving the reliability/quality of California's electricity by providing information and tools for cost-effective vegetation management practices for identifying and controlling vegetation that poses a risk to the transmission system.

**Proposed Outcomes:**

1. Provide information and tools to support cost-effective and environmentally sound ROW management practices.
2. Develop tools for cost-effective identification of danger trees and other ROW-bordering vegetation posing a risk to the transmission system.
3. Develop new approaches for reducing negative interactions between birds and transmission/distribution structures, wind turbines, and communications towers.

**Actual Outcomes:**

1. Information and Tools for Environmentally Sound, Cost-effective ROW Management.
  - EPRI produced a technical update document, *Wildlife and Integrated Vegetation Management on Electric Transmission Line Rights-of-Way* (1005366), that describes integrated vegetation management (IVM) methods and discusses the role of IVM in maintaining biodiversity as well as ecosystem integrity and function.

- EPRI published a report, *Best Management Practices (BMPs) Manual for Access Road Crossings of Wetlands and Waterbodies* (1005188), in March 2002. The manual addresses the selection and use of best management practices for the construction and/or maintenance of wetland and waterbody crossings by access roads associated with electric utility lines. Although the focus of this manual is on electric utility access roads, the contents are likely to be applicable to a much broader range of linear projects, including other types of roads and projects. The publication received the 2002 "Outstanding Environmental Resource Document" award from the San Diego chapter of the Association of Environmental Professionals.
  - In 2002 EPRI published the proceedings from the Seventh International ROW Symposium, which brought together worldwide experts who shared and debated new ideas for managing ROWs. The publication, *Environmental Concerns in Rights-of-Way Management: Seventh International Symposium: 9 - 13 September 2000, Calgary, Alberta, Canada* (1006500), presents 101 peer-reviewed papers on current environmental issues involved in rights-of-way management.
2. Danger Tree Assessment.
- A new version of Airborne Inspection System (AIS) software (1005376) was developed to support evaluation of vegetation conditions from digitized data collected using airborne imaging technology. This will allow quick location and assessment of danger trees in a cost-effective manner during ROW construction and maintenance.
3. Avian Interactions.
- A workshop on Avian Interactions with Wind Power Structures was held October 16-17, 2002, and drew more than 130 attendees from the United States and abroad.
  - A technical update – the proceedings from the above workshop, which will have the same title (1005384) – will be available in April 2003. The document will provide guidance for assessing, preventing, and reducing bird and bat mortality at wind-power facilities.
  - A technical report – *Bird Strike Indicator/Bird Activity Monitor and Field Assessments of Avian Mortality* (1005385) – which is in preparation, describes case studies and provides new information on ways to avoid and/or mitigate avian interactions with power structures.
  - A master's thesis titled “Assessment of Bat Community Structure and Roosting Habitat Preferences for the Hoary Bat (*Lasiurus cinereus*) Near Foote Creek Rim, Wyoming,” was successfully defended in September 2002 at the Department of Zoology and Physiology of the University of Wyoming by candidate Jeffrey C. Gruver. This thesis will be published as an EPRI report in 2003. The document provides previously unknown information on bat ecology that is relevant to wind power development.

**Project Status:**

This project has been completed.

**Section 316(a) and (b) Fish Protection Issues – Program 54**

**Contract #:** 500-00-023 **Project #:** 55

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

**Subcontractors:** Alden Research Laboratory, Inc. : Applied Biomathematics, Inc : ASA  
Analysis & Communication : Argonne National Laboratory : Langhei Ecology LLC : Louisiana  
State University : UT-Battelle LLC (Oak Ridge National Laboratory) : Webster Van Winkle :  
LWB Environmental Services : Ivar Strand

**Project Amount:** \$236,395

**Match Amount:** \$3,109,764

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Completed

**Project Description:**

The purpose of this project is to support cost-effective fish protection and facility operational decision-making. The protection of single fish species and aquatic communities is a primary focus of water permitting for coal, oil, gas, and nuclear power plants and industrial facilities under Clean Water Act Section 316(a) (heated and chlorinated cooling water discharges), and Section 316(b) (entrainment into intakes and impingement on intake screens). This project provides methods for studying fish entrainment and impingement mortality and generating results for fish population predictions that will be used to address biological community and biodiversity risks associated with power plants and industrial facilities. The project also evaluates the effectiveness of cooling water intake fish protection technologies such as cylindrical wedge wire screens, bar racks/louvers, and aquatic filter barriers.

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

- Improving the environmental costs/risks of California's electricity by studying how to reduce the negative effects of thermal power plants (using once-through cooling) on aquatic resources in freshwater and marine environments.
- Improving the public health costs/risks of California's electricity by protecting fish in cost-effective ways to minimize environmental impacts on aquatic environments that impact humans.

**Proposed Outcomes:**

1. Produce a fish protection synthesis report that integrates all the information collected and developed in response to this issue for the purpose of regulatory development and implementation of those regulations.
2. Sponsor workshops and national conferences to explore technical issues related to Section 316(a) and (b) regulatory developments.
3. Provide guidance for the selection and application of aquatic ecosystem evaluation methods. Of particular importance is the utility of bioassessment criteria as screening tools for determining the potential for adverse environmental impacts for once-through cooling water operations.
4. Provide an assessment of compliance options for fish protection through the use of an intake structure database to inform science-based, cost-effective regulatory decision-making.
5. Develop risk assessment framework information applicable to Section 316(a) and (b) demonstrations, and endangered and threatened species issues.
6. Evaluate and enhance cost-effective current and emerging technologies for protecting fish at cooling water intake structures.

7. Provide guidance for monitoring of entrainment and impingement mortality, and selection of appropriate BTA (best technology available) technologies for evaluation.
8. Provide guidance on suitable cost-benefit analysis for BTA determinations.

**Actual Outcomes:**

1. 316(b) Fish Protection Synthesis Report.
  - An interim technical report, *Enhancement Strategies for Mitigating Potential Operational Impacts of Cooling Water Intake Structures: Approaches for Enhancing Environmental Resources* (1005326), was published. The report describes environmental enhancement or restoration approaches that may be applicable for mitigating impingement and entrainment impacts associated with cooling water intake structures (CWISs).
  - A final report, *Enhancement Strategies for Mitigating Potential Operational Impacts of Cooling Water Intake Structures: Approaches for Enhancing Environmental Resources* (1007454) was published at the end of 2002.
2. Workshops/Conferences on Water Use Impacts on Aquatic Resources.
  - A symposium on *Defining and Assessing Adverse Environmental Impact under Section 316(b) of the Clean Water Act* was held in conjunction with the American Fisheries Society Annual Meeting, August 2001. Papers from this symposium were submitted to a publisher, were peer-reviewed and published both in electronic format and in a printed book.
  - Aquatic Ecosystem Evaluation Methods.
  - EPRI reviewed the impacts of CWIS operation for each major water body type and published results in a report – *Technical Summary of Environmental Impacts from CWIS Operation* (1005178).
3. Intake Structure Database.
  - A technical update document was prepared that provides an informal progress report on development of the Entrainment and Impingement Database. This database has been further developed this year in support of projects to evaluate entrainment and impingement mortality.
4. Ecological Risk Assessment Frameworks.
  - A report—*Evaluating the Effects of Power Plant Operations on Aquatic Communities: An Ecological Risk Assessment Framework for Clean Water Act Section 316(b) Determinations* (1005176) was published in July 2002. The report describes a general framework for ecological risk assessment proposed by the U. S. Environmental Protection Agency and explains how this framework can be integrated into the decision-making process under Section 316(b). This report complements EPRI reports TR-112013 and 1005176. These three reports provide technically sound guidance for assessing the potential for adverse environmental impact resulting from cooling water withdrawals and evaluating the potential ecological benefits of mitigation alternatives.
  - A report, *Connecticut River Ecological Study Workshop: Revisiting the Impact of a Power Plant: November 15-16, 2001, The University of Connecticut Marine Sciences Institute at Avery Point* (1006900) was published. The report summarizes a technical workshop held November 15-16, 2001 at the decommissioned Connecticut Yankee plant to review a previous Connecticut River ecological study. The workshop examined the long-term impacts of the plant and the current status of fish populations in the river.

5. Intake Fish Protection.
  - In research cofunded with EPA, EPRI investigated the efficacy of cylindrical wedge wire screens for protecting fish at water intakes. Research began in 2001 and concluded in December 2002. Preliminary results were presented in August at the annual meeting of the American Fisheries Society. A technical report, *Evaluation of Cylindrical Wedge-Wire Screens* (1005339) was drafted and submitted for publication in December 2002.
  - EPRI began flume tests to characterize performance and physical properties of a new entrainment technology, the aquatic filter barrier.

**Project Status:**

This project has been completed.

## **Sediment Issues at California Hydroelectric Facilities**

**Contract #:** 100-98-001 **Project #:** 46

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

**Subcontractors:** Alden Research Laboratory, Inc.

**Project Amount:** \$37,500

**Match Amount:** \$37,500

**Contractor Project Manager:** Doug Dixon (804) 642-1025

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Completed

### **Project Description:**

The purpose of this project is to evaluate sedimentation problems at California's hydropower facilities. A 1995–96 survey by the Federal Energy Regulatory Commission (FERC) indicated that approximately one in four reservoirs in the United States had sedimentation problems, including environmental degradation, contaminated sediments, and operational loss. Sediment loading threatens environmental resources and the continued viability of hydroelectric generation. To ensure environmentally sound and productive hydropower generation in California, researchers need to identify the nature and extent of sedimentation problems at California's hydropower facilities.

In this project, PIEREA and EPRI are examining sediment issues (e.g., loading, contamination, gravel trapping, potential fish and aquatic impacts, and removal options) at hydropower facilities in California. The team is characterizing sedimentation issues—including the nature and extent of problems and remedial actions undertaken or planned—at all FERC-licensed and federal California hydropower operations via an electronic questionnaire and follow-up phone interviews. Researchers will also review and summarize environmentally responsible remedial strategies and develop a framework for sediment management guidelines for California hydroelectric and other water resource operations.

The project will establish a database on the nature and extent of sedimentation problems at California hydroelectric facilities, and will publish a report characterizing sedimentation issues at California hydroelectric facilities.

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

- Providing environmentally sound electricity by providing the information necessary to implement environmentally responsible mitigation measures through characterizing the sedimentation at California's dams.
- Ensuring reliable energy services by developing remedial measures to reduce sedimentation that will lead to greater generation capacity at California's hydro facilities.

### **Proposed Outcomes:**

1. Increased output from hydroelectric dams. Mitigation strategies that will enable hydropower operators to remove sediments with less risk to aquatic organisms will help operators increase electricity production. The information will be particularly useful California's hydroelectric facilities that must renew their licenses by 2010.
2. Decreased environmental impacts from contaminated sediments. This information will provide California's water resource managers with information to plan appropriate actions to prevent or mitigate sediment-related problems.

**Actual Outcomes:**

In 2001 PIEREA and EPRI examined and characterized sediment issues at hydropower facilities in California, reviewed environmentally responsible remedial strategies, developed a framework for sediment management guidelines, and prepared a final report describing project findings. The draft final report from this effort was delivered to the Commission for review in early 2002. Because of the low response rate to the survey, the Commission decided not to finalize the report.

**Project Status:**

EPRI is currently investigating the feasibility of increasing the response rate via an informal phone survey of California hydroelectric operators. This phone survey is being conducted via EPRI base funds. The Commission's involvement has ended for the time being.

## **TMDL, Watershed, and Ecosystem - Program 55**

**Contract #:** 500-00-023 **Project #:** 56

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

**Subcontractors:** Systech Engineering, Inc. : Tetra Tech, Inc. : University of California, Santa Barbara : Humboldt State University : Freshwater Institute (Canadian Dept. of Fisheries and Oceans) : University of Maryland : Resources Strategies, Inc.

**Project Amount:** \$135,300

**Match Amount:** \$1,454,682

**Contractor Project Manager:** Robert Goldstein (650) 855-2593

**Commission Contract Manager:** Kelly Birkinshaw (916) 654-4542

**Status:** Completed

### **Project Description:**

This program delivers scientific information, guidance, and tools to support cost-efficient, risk-based strategies for integrated watershed management and ecosystem protection.

Momentum is building for a more integrated framework for environmental management and protection. Environmental regulations and initiatives are being developed whose scope goes beyond the protection of individual waterways and species to focus on entire watersheds and ecosystems. Controls are also under consideration for nonpoint sources of pollution such as air emissions from industry and transportation. The integrated watershed/ecosystem management approach encompasses emerging issues such as mercury and nitrogen atmospheric deposition, coastal water eutrophication, water quality trading, water resource sustainability under growing demand for water use, and analysis and allocation of total maximum daily load (TMDL—the maximum influx of contaminants a water body can receive without damage). This program delivers knowledge and tools for calculating TMDLs, analyzing allocation strategies, assessing the ecological effects of nonpoint sources of pollution, and implementing water quality trading strategies.

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

- Improving the environmental costs/risks of California's electricity by providing information and tools that enable companies, regulators, and stakeholders to assess cumulative impacts and risks on a facility-specific and watershed-wide basis, analyze the costs and benefits of management alternatives, and implement cost-efficient management strategies.
- Improving the public health costs/risks of California's electricity by providing integrated strategies to minimize environmental impacts on watersheds and ecosystems that may affect humans.

### **Proposed Outcomes:**

1. Provide an analytic framework (the EPRI Watershed Analysis Risk Management Framework: WARMF) to support the watershed approach and TMDL calculations. WARMF is a decision support system for assessing integrated effects and evaluating alternative management strategies for the diverse array of pollutant sources (point and nonpoint) within a watershed. It also provides a structured approach for building consensus among stakeholders.
2. Provide methods and data to assess the influence of atmospheric deposition and other nonpoint source pollution on the ecological health of watersheds, estuaries, wetlands, and lakes.

3. Develop information and methods to support the application of market-based strategies for sustainable ecological resource management and water quality trading.

**Actual Outcomes:**

1. TMDL/Watershed Analysis:
  - EPRI published report – *A Review of Total Maximum Daily Load (TMDL) Program: An Assessment of States' Implementation of Section 303(d) of the Clean Water Act* (1005343) in October 2002. The report reviews accessible TMDL reports, summarizes the EPA's TMDL program, outlines potential impacts of TMDLs on the electric power industry, and identifies research and other action needed to strengthen the TMDL program. This report will be valuable to industry, agriculture, and environmentalist and government organizations involved in management and protection of watershed resources and compliance with water quality criteria.
  - EPRI published a report – *TMDL Consensus Simulation Workshop Using WARMF Framework* (1005498) – that presents results of a workshop to test the consensus-building module of EPRI's Watershed Analysis Risk Management Framework (WARMF). The workshop focused on WARMF as a decision-support tool. In particular, it focused on the use of the Consensus Module to provide information needed to define various stakeholder positions and communicate information needed to understand the watershed and its response to various management alternatives. The workshop's objective was to have real stakeholders evaluate the Consensus Module within the context of a simulated, realistic application. Workshop results will prove valuable to industry, agriculture, environmental groups, and government agencies involved in managing and protecting watershed resources and complying with water quality criteria.
  - EPRI published report – *Comparison of BASINS and WARMF Models: Mica Creek Watershed* (1005344). The report documents fundamental differences in how the two watershed models are conceptualized, calibrated, and applied. This information will be useful to stakeholders including industrial, agricultural, environmental, and governmental organizations concerned with TMDLs.
  - EPRI published a four-volume EPRI Report on Water & Sustainability:
    - Volume 1: *Research Plan* (1006784).
    - Volume 2: *An Assessment of Water Demand, Supply and Quality in the U.S. – The Next Half Century* (1006785).
    - Volume 3: *U.S. Water Consumption for Power Production – The Next Half Century* (1006786).
    - Volume 4: *U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century* (1006787).
  - The following peer-reviewed papers were produced:
    - Herr, J., C. Chen, R. A. Goldstein, R. Herd, and J.M. Brown. "Modeling Acid Mine Drainage on a Watershed Scale For TMDL Calculations," *Journal of American Water Resources Association*, (in press).
    - Herr, J, C. Chen, R.A. Goldstein, and J.N. Brogdon. "A Tool for Sediment TMDL Development on Oostanaula Creek, In Total Maximum Daily Load (TMDL) Environmental Regulations," *Proceedings of March 11-13, 2002 Conference, Society for Engineering in Agriculture, Food, and Biological Systems*, ASAE Publication 701P0102, pp. 111-116 (2002).
2. Watershed Assessment of Atmospheric Deposition and other Nonpoint Source Pollution.
  - In 2002 the project team enhanced EPRI's Estuary Eutrophication Framework to address the cycling and effects of atmospheric deposition of mercury in addition to

nitrogen and phosphorous. A technical report presenting the results is scheduled for publication in March 2003.

- A group of expert scientists identified research needs and developed an experimental design to quantify the fate of atmospherically deposited nitrogen compounds. Results will be presented in an informal technical progress report, *Nitrogen Stable Isotope Tracer Research Design* (1005349).
  - EPRI-funded research produced the following peer reviewed publications:
  - "Inputs and Outputs of Mercury from Terrestrial Watersheds: A Review." D.F. Grigal. *Environmental Reviews*, 10, pp. 1-39 (2002).
  - Babiarz, C.L., J.P. Hurley, D.P. Krabbenhoft, C. Gilmour, and B. Branfireun. "Application of Ultrafiltration and Stable Isotopic Amendments to Field Studies of Mercury Partitioning to Filterable Carbon in Lake Water and Overland Runoff." In J. Munthe (ed.), *Proc. 6<sup>th</sup> International Conference on Mercury as a Global Pollutant*. Minimata, Japan, Oct 15-19, 2001. Published in *Science of the Total Environment*. This publication was produced by the METAALICUS project that is cofunded by Program 55.
  - "Mercury Sequestration in Forests and Peatlands: A Review," D.F. Grigal. *Journal of Environmental Quality* (in press).
3. Sustainable Ecological Resource Management and Effluent Trading.
- EPRI published a technical report – *Water Quality Trading Guidance Manual* (1005179) that provides water quality trading program developers with an overview of issues they will need to address and summarizes relevant lessons from existing water quality trading programs.
  - EPRI developed a technical report – *Modeling Methods for Water Quality Trading* (1005350) – that will describe the use of models to support the development and implementation of effluent trading programs. It will be available in the first quarter of 2003.

**Project Status:**

The following research and activities that took place in 2002 will produce publications in later years:

1. WARMF case studies in North Carolina, South Carolina, Tennessee, Nebraska, Minnesota, Wisconsin, and Colorado. The Colorado study is funded by a USEPA grant. The others are funded by tailored collaboration (TC).
2. Development of eco-indices to support water quality trading. TC funded.
3. Study of feasibility of water quality trading. TC funded.
4. Study of major environmental issues for different industry sectors in a common watershed. TC funded.
5. Development of methods using stable isotopes to identify pollutant sources.
6. Participation in the Federal Advisory Committee on Water Information and the Sustainable Water Resources Round Table.
7. Member support.

**TMDL, Watershed, and Ecosystem Issues - Target 55**

**Contract #:** 500-00-023 **Project #:** 21

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

**Subcontractors:** Systech Engineering, Inc. : Tetra Tech, Inc. : University of California, Santa Barbara : California State University, Humboldt : Fresh Water Institute : University of Maryland : Resource Strategies, Inc.

**Project Amount:** \$135,300

**Match Amount:** \$1,959,583

**Contractor Project Manager:** Robert Goldstein (650) 855-2593

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

This program delivers scientific information, guidance, and tools to support cost-efficient, risk-based strategies for integrated watershed management and ecosystem protection.

Momentum is building for a more integrated framework for environmental management and protection. Environmental regulations and initiatives are being developed whose scope goes beyond the protection of individual waterways and species to focus on entire watersheds and ecosystems. Controls are also under consideration for non-point sources of pollution such as air emissions from industry and transportation. The integrated watershed/ecosystem management approach encompasses emerging issues such as coastal water eutrophication, effluent trading, and analysis and allocation of total maximum daily load (TMDL—the maximum influx of contaminants a water body can receive without damage). This program delivers knowledge and tools for calculating TMDLs, analyzing allocation strategies, assessing the ecological effects of non-point sources of pollution, and implementing effluent trading strategies.

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

- Improving the environmental costs/risks of California's electricity by providing information and tools that enable companies, regulators, and stakeholders to assess cumulative impacts and risks on a facility-specific and watershed-wide basis, analyze the costs and benefits of management alternatives, and implement cost-efficient management strategies.
- Improving the public health costs/risks of California's electricity by providing integrated strategies to minimize environmental impacts on watersheds and ecosystems that may affect humans.

**Proposed Outcomes:**

1. Provide and support an analytic framework (the EPRI Watershed Analysis Risk Management Framework, WARMF) to support the watershed approach and TMDL calculations. WARMF is a decision support system for assessing integrated effects and evaluating alternative management strategies for the diverse array of pollutant sources (point and nonpoint) within a watershed. It also provides a structured approach for building consensus among stakeholders.
2. Provide methods and data to assess the influence of atmospheric deposition and other nonpoint source pollution on the ecological health of watersheds, estuaries, wetlands, and lakes.
3. Develop information and methods supporting the application of market-based strategies for ecological resource management and effluent trading.

**Actual Outcomes:**

1. Watershed Analysis Risk Management Framework.
  - A report – *Watershed Analysis Risk Management Framework (WARMF): Update One: A Decision Support System for Watershed Analysis and Total Maximum Daily Load Calculation, Allocation, and Implementation* (1005181) – was published. The report documents and illustrates the application of EPRI's WARMF decision support software to conduct TMDL analyses and allocate TMDLs among stakeholders.
  - A report – *Peer Review of the Acid Mine Drainage Module of the Watershed Analysis Risk Management Framework (WARMF): An Evaluation of WARMF/AMD Using EPA Guidelines* (1005182) – was published. The report contains results of an EPA-requested peer review, using EPA guidelines and independent experts., of WARMF's Acid Mine Drainage Module for use in developing TMDLs for watersheds where acid mine drainage is an important issue.
  - A WARMF training workshop was conducted to teach stakeholders, regulators, and students the underlying principles of TMDLs and watershed analysis and to train them in the use of the WARMF decision support system.
2. Watershed Assessment of Atmospheric Deposition.
  - A software product, *the Estuary Eutrophication Framework: General Version* (1001415), was developed. The software provides a user-friendly tool to estimate phosphorus and nitrogen loads to estuaries from land-based and atmospheric sources and to predict the impact of these nutrients on dissolved oxygen levels.
  - A workshop, *Nitrogen Stable Isotope Tracer Research Design*, was conducted to examine the state of the science and develop an experimental design to quantify the fates of atmospherically deposited nitrogen compounds.
3. Ecological Resource Management and Effluent Trading.
  - A report – *Water Quality Trading Guidance Manual: An Overview of Program Design Issues and Options* (1005179) – was published. The manual provides guidance on establishing new effluent trading programs, including identifying and resolving issues that could affect their development and use. The manual includes an overview of existing trading programs, information about completed trades, and a review of federal and state effluent trading regulations and policies.

**Project Status:**

This project has been completed.

**Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Strategies - (1999) TC Target 105**

**Contract #:** 100-98-001 **Project #:** 54

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

**Project Amount:** \$95,218

**Match Amount:** \$95,218

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

The purpose of this project is to develop alternative cooling strategies that do not require the large amount of water necessary to operate the traditional wet cooling tower systems used in thermal power plants.

Such alternative cooling technologies include dry and hybrid wet/dry cooling technologies. The current relative costs and performance of dry, hybrid wet/dry cooling technologies are not as attractive as those of wet cooling towers, however, these associated disadvantages may be outweighed by the potential benefits of diverting the supply of relatively high quality water to other sectors with essential, high demands for fresh water. In all sectors of the economy, we need to examine the use of water and ensure that alternatives are identified or developed to facilitate the most efficient and beneficial use of this valuable resource. This project is designed to address this issue by identifying the tradeoffs between alternative cooling technologies.

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

- Providing safe, environmentally sound electricity by identifying effective, economical alternatives to wet cooling that could greatly reduce the amount of fresh water needed for power plant cooling. Additionally implementing these alternative technologies will help eliminate environmental impacts associated with wet cooling technologies, and potentially help expedite power plant siting.
- Providing reliable energy by using alternative cooling systems that do not require large quantities of water, which enables power producers to construct sufficient capacity to meet California's electricity needs without impinging on local water supplies.
- Providing affordable energy by identifying the most economical alternative cooling technologies, which means that power plants and California could reap the benefits of less water use at the lowest possible cost.

**Proposed Outcomes:**

1. Reduced use of fresh water for thermal power plant cooling. Dry and hybrid wet/dry power plant cooling technologies can reduce cooling water consumption more than 90 percent, compared to current wet cooling towers. If the more than 22,000 MW of projected new and replacement electricity generation for California used dry cooling, approximately 140,000 acre-feet per year of fresh water could be used for other purposes.
2. A more informed and rapid power plant licensing process. The project will result in an objective data set for comparing the fiscal and performance costs of alternative cooling technologies for power plants—which will contribute to the discussion of technical and fiscal merits of alternative cooling technologies and their potential for saving water. The formulation of an objective data set will reduce the regulatory uncertainty for new power plant licensing.

3. Lowest-cost effective alternatives. Installed cost for a wet cooling system for a 500-MW combined cycle power plant is about \$4-5 million. Dry cooling alternatives may cost 2-3 times that much, with accompanying efficiency losses. Identifying the lowest cost and most effective options will facilitate installation of these systems.

**Actual Outcomes:**

To evaluate alternative cooling systems, PIEREA and EPRI:

1. Defined and compared the current costs and performance of the dry and hybrid wet/dry cooling towers, relative to wet cooling towers.
2. Identified the environmental benefits and trade-offs between wet, dry, and hybrid wet/dry cooling towers.
3. Identified future research that can improve the costs and performance of wet, dry, and hybrid wet/dry cooling towers.
4. Identified other alternative power plant cooling technologies that can improve the environmental and public health costs and risks from producing electricity in California.

**Project Status:**

The final report on the results of this work was peer reviewed and delivered to Commission in 2002 and is currently on the PIER web-site. This project has been completed.

## **ENV Projects Completed in 2001**

## Facilities Water Management - Target 56

**Contract #:** 500-00-023 **Project #:** 22

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

**Subcontractors:** John S. Maulbetsch : University of Southern California : Waters Edge Technology LLC

**Project Amount:** \$62,196

**Match Amount:** \$1,553,735

**Contractor Project Manager:** Rick Carlton (650) 855-2115

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

### Project Description:

The purpose of this project is to develop and implement cost-effective strategies for controlling biofouling, treating wastewater, and treating and recycling cooling water while maintaining minimal impact on the environment. This EPRI target will focus on strategies that include reducing biocide discharges, removing heavy metals, minimizing nitrogen compounds to reduce eutrophication (an aquatic environment wherein plant life is favored over animal life) of water resources, and reducing bioaccumulative pollutants from plant wastewater. For example, EPRI has demonstrated the use of constructed wetlands for treatment of point- and non-point source aqueous discharges.

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

- Improving the energy cost/value of California's electricity by developing cost-effective alternative water sources and alternative technologies/methods of treatment of these alternative water sources. The purposes of these alternatives are to minimize environmental impact at reduced costs for treatment of cooling water and increased water recycling/reuse, while improving plant performance and preventing corrosion damage.
- Improving the environmental and public health costs/risks of California's electricity by providing solutions that reduce or eliminate the water-related impacts of electricity generation in California.

### Proposed Outcomes:

1. Provide biofouling control and plant performance strategies.
2. Provide information and methods for designing constructed wetlands as a low-cost alternative for meeting water quality standards.
3. Conduct a Tailored Collaboration entitled "Degraded or Reclaimed Power Plant Cooling Water."
4. Conduct a Tailored Collaboration entitled "Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Technologies."

### Actual Outcomes:

1. Biofouling Control.
  - The 11<sup>th</sup> International Zebra Mussel Conference was cosponsored by EPRI.
  - A biofouling control conference was cosponsored by EPRI.
2. Constructed Wetlands.
  - A report—*Phytoremediation of Trace Elements by Wetland Plants* (1005185)—was published. The report describes research to quantify the capacity of various wetland plant species to remove trace elements from polluted water.

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3. Tailored Collaboration – Degraded or Reclaimed Power Plant Cooling Water.
  - The final report on the results of this work was delivered in 2002.
4. Tailored Collaboration – Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Technologies.
  - Research was conducted to evaluate the tradeoffs between alternative cooling technologies. Findings are presented in a report that was peer-reviewed and delivered in 2002.

**Project Status:**

This project has been completed.

**Rights-of-Way Environmental Issues in Siting, Development, and Management:  
Avian Interactions With Utility Structures, Wind Turbines, and Communication  
Towers Tailored Solution Package - Target 57**

**Contract #:** 500-00-023 **Project #:** 23

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

**Subcontractors:** EPRI Solutions : Resource Strategies, Inc. : URS Greiner Woodward Clyde : EDM International, Inc. : Western EcoSystems Technology, Inc.

**Project Amount:** \$31,690

**Match Amount:** \$699,825

**Contractor Project Manager:** John Goodrich-Mahoney (650) 855-5256

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

**Project Description:**

This program's tools and information support rights-of-way (ROW) practices that protect the environment while controlling costs associated with ROW siting, development, and management. Environmental issues confronting ROW owners and users include avian interactions (bird collisions, nesting and perching) with power and communications structures environmental impacts of access roads, biodiversity and habitat fragmentation. Concurrently, ROW siting, development, and management are increasingly guided by government policies and regulations. Competitive markets demand reliable, high-quality electrical service while compelling companies to be ever mindful of capital and operational budgets. Dealing with these challenges requires balancing cost-effectiveness with compliance, environmental stewardship, and responsiveness to the public. This program develops and delivers scientific information and innovative approaches to help ROW owners/users contain costs while responding to the competitive marketplace and practicing environmental stewardship.

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

- Improving the environmental costs/risks of California's electricity by providing information and methods that enable companies, regulators, and stakeholders to assess, minimize, and mitigate environmental impacts associated with rights of way and to implement cost-effective ROW management strategies.
- Improving the reliability/quality of California's electricity by providing information and tools for cost-effective vegetation management practices for identifying and controlling vegetation that poses a risk to the transmission system.

**Proposed Outcomes:**

1. Provide information and methods to address rights-of-way environmental and land-use issues to enhance the ROW environment and to avoid or mitigate environmental impacts.
2. Develop information on reducing negative interactions between birds and transmission/distribution structures, wind turbines, and communications towers.
3. Provide information and tools to support cost-effective and environmentally sound ROW vegetation management practices.
4. Develop information for cost-effective identification of danger trees and other ROW-bordering vegetation posing a risk to the transmission system.
5. Evaluate the impacts of access road construction at stream crossings and through wetlands.
6. Provide a detailed plan for integrating public communications into ROW projects.

**Actual Outcomes:**

1. Rights-of-Way Environmental and Land Use Issues.
  - A software product – *The Rights-of-Way Bibliographic Database, Version 1.0* (1005190) – was developed and released. The software provides a convenient information resource to support cost-effective and environmentally sound ROW management practices.
- Avian Interactions.
  - A report – *Avian Interactions with Utility and Communication Structures: Proceedings of a Workshop Held in Charleston, South Carolina, December 2-3, 1999* (1005180) – was published with support by the Avian Power Line Interaction Committee of the Edison Electric Institute. The report includes manuscripts or abstracts of the workshop's 24 presentations, which addressed a wide range of subjects including interactions between bats and utility structures, cooperative approaches to solving avian interaction problems, and legal aspects of avian interactions with manmade facilities.
- Vegetation Management.
  - A report – *Vascular Species Richness and Rarity in Wetlands on Electric Power Rights of Way in New York State* (1005187) – was published. The report examines the impact of ROW construction and management on plant diversity and vascular species richness.
  - A report – *Rights of Way Mechanical Cutting and Disposal Costs—Update 2001* (1005186) – was published. The report updates earlier research to determine the factors influencing ROW cutting and disposal costs.
  - EPRI cosponsored the Seventh International Symposium on Environmental Concerns in Rights-of-Way Management. Papers presented at the conferences were submitted for publication.
- Danger Tree Assessment.
  - A report – *Airborne Inspection System (AIS) Version 2.0 Product Specifications* (1005191) – was published. The report details the proposed functions and features of the AIS, a software tool that offers an efficient way to use digital aerial patrol data—including high-resolution imagery, digital video, and GPA coordinates—for cost-effective identification of vegetation posing a risk to the transmission system.
- Impacts of Road Construction.
  - Research was conducted to evaluate regulatory issues (including a critical evaluation of all mandated best practices), cost implications, and environmental concerns related to development of access roads in the vicinity of water bodies. Results are presented in a report – *Best Practices Manual for Access Road Crossings of Wetlands and Waterbodies* (1005188) - published in March 2002.
- Public Communications.
  - A report – *Communicating with the Public About Rights of Way: A Practitioner's Guide* (1005189) – was published. The report describes a systematic eight-step template for planning ROW public communications to improve the public dialog concerning ROW issues.

**Project Status:**

This project has been completed.

**Water Quality Criteria and Toxics In Aquatic Environments - Target 53**

**Contract #:** 500-00-023 **Project #:** 19

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

**Subcontractors:** Battelle Memorial Institute : Dr. Stephen J. Klaine : Fresh Water Institute : Great Lakes Environmental Center : K.S. Crump Group : Tetra Tech, Inc. : University of Wisconsin Systems : Water Environment Research Foundation

**Project Amount:** \$103,525

**Match Amount:** \$1,604,494

**Contractor Project Manager:** John Goodrich-Mahoney (202) 293-7516

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

The purpose of this project is to provide the Energy Commission with information and tools to help improve the scientific basis for California water quality criteria. The products of this target may also facilitate the use of site-specific conditions and new data to assess the impacts of toxic chemicals in California's aquatic environments. Findings can be applied directly to meet specific technical challenges. They are also useful to the regulatory and scientific communities, helping to inform ongoing deliberations, and to increase understanding of critical issues.

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

- Improving the environmental and public health costs/risks of California's electricity by providing tools that lead to more precise estimates of human health and ecological risks and establish the basis for more cost-effective regulations and compliance methods.

**Proposed Outcomes:**

1. Apply the Mercury Cycling Model—which predicts ecosystem responses to changing mercury loadings—in field tests to improve its representation of mercury cycling through lakes and streams.
2. Support research to develop a scientifically sound approach to site-specific permitting of selenium discharges to streams and rivers.
3. Develop a technical report on the biological criteria development process to reduce regulatory uncertainty and associated costs.
4. Conduct a Tailored Collaboration entitled "Sedimentation Issues at Hydro-electric Facilities."

**Actual Outcomes:**

1. A technical report, "Controls on Fluxes of Mercury in Aquatic Food Webs: Application of the Dynamic Mercury Cycling Model to Four Enclosure Experiments with Additions of Stable Mercury Isotopes," (1005171) was published. The report describes a pilot study that demonstrated the efficacy of using stable mercury isotopes in large-scale, in situ, process-level experiments investigating mercury cycling in natural ecosystems. Results of the pilot study were critical to the design of a full-scale experiment designed to address the question of what happens to fish mercury concentrations when there is a change in atmospheric mercury deposition.
2. A workshop on selenium dynamics in running waters enabled researchers, EPA, and stakeholders to review results from prior research activities and fine tune the research program for the next year. Workshop proceedings were published in 2002.
3. A technical report, "*Selenium Cycling and Impact in Aquatic Ecosystems: Defining Trophic Transfer and Water-Borne Exposure Pathways*," (1005217) was published. The

report concludes that selenite-exposed algae produce higher levels of Selenium in zooplankton than do algae exposed to equivalent concentrations of selenate.

4. A technical report describing field evaluations of the biological criteria development process was published in 2002.

**Project Status:**

This project has been completed.

## **ENV Projects Completed in 2000**

## **Air Toxics Health and Risk Assessment - Target 91**

**Contract #:** 100-98-001 **Project #:** 20

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

**Subcontractors:** Atmospheric & Environmental Research, Inc. : Exponent Failure Analysis Associates : Golder Associates, Inc. : ICF Kaiser Engineers : Lockheed Martin Energy Systems, Inc. : Raptor Research Project : SCOPE : Tetra Tech, Inc. : University of Connecticut : University of Maryland : University of Nevada, Reno : University Of Rochester : Wisconsin Department of Natural Resources.

**Project Amount:** \$480,000

**Match Amount:** \$3,231,763

**Contractor Project Manager:** Leonard Levin (650) 855-7929

**Commission Contract Manager:** Obed Odoemelam (916) 654-4171

**Status:** Completed

### **Project Description:**

The purpose of this project is to determine whether trace substances emitted by power plants may be deposited near the emissions sources or be transported over great distances. At issue is whether power plant contributions pose concerns for human health and environmental quality. Currently, air toxics such as dioxins, arsenic, nickel, and especially mercury are of growing regulatory, public, and economic concern. Recent U.S. EPA reports to Congress address the relationship between these toxics and power plant emissions, and call for extensive research into several key questions: How toxic is the material emitted by power plants? To what extent, and by what means, are people exposed to that material? How can a realistic estimate of quantitative risk be derived? What risks are significant? Basic scientific understanding of these issues is critical to the energy industry.

The primary focus of this EPRI target is filling gaps in scientific and health information. EPRI research is designed to inform energy companies and policy-makers of the health and environmental basis for potential risks associated with air emissions and, when appropriate, to examine practical management solutions. This target, combined with the other EPRI research on air toxics measurement and control, provides a total integrated response to the issues cited above. EPRI's comprehensive risk-assessment framework has also been critical in supporting informed and cost-effective community health decisions. By providing objective and timely information, EPRI promotes science-based decision making on air toxics.

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

- Improving the environmental and public health costs/risks of California's electricity by providing science-based assessment of air toxics health and risk impacts.
- Improving the safety of California's electricity by assessing the risk of power generation with regard to air toxics, by providing science-based assessment of air toxics health and risk impacts.

### **Proposed Outcomes:**

1. Provide advanced tools and data to evaluate public exposure to mercury and other substances, including dioxins, with significant non-inhalation exposure routes.
2. Quantify atmospheric mercury concentrations and deposition in time and space to establish local versus regional/global influence.
3. Evaluate natural mercury emissions to provide a more accurate context for perspectives on power plant mercury emissions.
4. Determine source-receptor relationships for air toxics (with emphasis on mercury).

5. Assess health effects of nickel exposure.
6. Assess health effects of exposure to arsenic and other air toxics.
7. Provide data enhancements to the Mercury Cycling Model System.
8. Update and refine the Comprehensive Risk Assessment Framework for Toxics (CRAFT) model.
9. Evaluate ecosystem effects of mercury exposure by performing an ecological risk assessment of mercury impacts on fish-eating wildlife.
10. Determine environmental consequences of ecological and human exposure to multiple toxic agents, including arsenic, mercury, and selenium.
11. Conduct a Tailored Collaboration entitled "Risk Evaluation of Chemicals Used in the Photovoltaic Industry in California" in order to identify chemicals used in PV cells and their potential for release to the environment, and to identify PV cell technologies that have a relatively lower toxic risk compared to other cell types.

**Actual Outcomes:**

1. The EPRI TRUE multimedia model was extended for exposure to dioxins, by specifying congener-specific dynamics, and was adapted to the Mercury Cycling Model for lake-specific outcomes.
2. Quantifying atmospheric mercury concentrations and deposition.
3. Information was compiled from continuous measurement of wet deposition of mercury at the Covelo, California, deposition monitoring station.
4. Field measurements of mercury source terms were conducted in central coastal California and at sites in the eastern Sierra, which were disturbed by mineral recovery operations over the last 150 years.
5. Natural mercury emissions were evaluated, and a research project by EPRI staff was published in 2000, indicating contributions to mercury deposition by background emissions.
6. Additional case studies and a national study were carried out, establishing the contribution of local and international sources to U.S. mercury deposition. A report was issued in December 2000.
7. A report was published on the comparative carcinogenicity of nickel compounds.
8. Proceedings were published from the Fourth International Conference on Managing Hazardous Air Pollutants.
9. D-MCM 1.0 was released for the Dynamic Mercury Cycling Model.
10. Additional specialized modules for CRAFT were developed in case studies. Full development has been postponed by resource limitations.
11. Extensive work on ecosystem risk is under way, with published results in 2000 on fish levels of mercury and on levels and effects in avian fauna.
12. Proceedings were published from the Fourth International Conference on Managing Hazardous Air Pollutants.
13. A final report for the tailored collaborative was published in 2001. See the separate write-up in this annual report under the title "Risk Evaluation of Chemicals Used in the Photovoltaic Industry in California".

**Project Status:**

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

## **Desert and Mountain Air Transport (DMAT)**

**Contract #:** 500-97-012 **Project #:** 6

**Contractor:** Edison Technology Solutions/Southern California Edison

**Subcontractors:** Electric Power Research Institute (EPRI) : South Coast Air Quality Management District

**Project Amount:** \$825,000

**Contractor Project Manager:** Vincent Mirabella (626) 302-9748

**Commission Contract Manager:** Tuan Ngo (916) 654-3852

**Status:** Completed

### **Project Description:**

The purpose of this project was to develop and apply new methods for characterizing and quantifying the regional transport and chemistry of visibility-impairing emissions (haze) leading to improvements in regional visibility in California. (Haze refers to atmospheric moisture, dust, smoke and vapor suspended to form a partially opaque visual condition). The modeling tools and methods developed under the DMAT Project will provide focus on the special visibility problems facing several Class I areas located in California as well as assist in developing assessment technologies for addressing the visibility problems facing urban areas of California.

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

- Improving environmental and public health costs/risk of California electricity by providing the knowledge of the transport and chemistry of visibility-impaired emissions to address the protection of visibility at mandatory federal Class-I areas in California and elsewhere.

### **Proposed Outcomes:**

1. Interpret inert tracer data released as part of the project to characterize the transport of emissions from various regions of the western United States.
2. Assess the reliability of currently available regional transport and chemistry visibility models.
3. Develop “conceptual models” to provide a fundamental understanding of the transport and chemical mechanisms that cause western visibility impairment.

### **Actual Outcomes:**

1. The DMAT study concluded that there is no direct relationship linking the emissions from a particular source to the regional visibility impairment in the Grand Canyon National Park.
2. The study concluded that the visibility impairment problem was caused by a combination of many industrial sources including those in Southern California, Northern Mexico and Las Vegas.
3. The analysis of inert tracer data is inconclusive and did not establish the reliability of current regional transport and chemistry visibility models. This is likely due to different mechanisms of sulfate formation chemistry in the clouds assumed in each model.
4. CALMET was determined to be the most successful model among the models used to generate the wind fields that affect the transport of air pollutants.
5. A conceptual model was developed and evaluated for simulating the formation of aerosols and photochemical ozone from a point source. Further testing is needed prior to the model being used on an operational basis.

### **Project Status:**

The project has been completed.

**Facilities Water Management - Target 105/46**

**Contract #:** 100-98-001 **Project #:** 16

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

**Subcontractors:** Di Filippo Michael : Lytle Mel C : Alabama Power Company : BetzDearborn, Inc. : Gannett Fleming, Inc. : Puckorius & Associates, Inc. : University of California, Berkeley : University of Iowa : University of Southern California : Water Systems Specialists, Inc.

**Project Amount:** \$110,400

**Match Amount:** \$1,674,490

**Contractor Project Manager:** Kent Zammit (650) 855-2097

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

The purpose of this project is to develop and implement cost-effective strategies for controlling biofouling, treating wastewater, and treating and recycling cooling water while maintaining minimal impact on the environment. This EPRI target will focus on strategies that include reducing biocide discharges, removing heavy metals, minimizing nitrogen compounds to reduce eutrophication (an aquatic environment wherein plant life is favored over animal life) of water resources, and reducing bioaccumulative pollutants from plant wastewater. For example, EPRI has demonstrated the use of constructed wetlands for treatment of point- and non-point source aqueous discharges.

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

- Improving the energy cost/value of California's electricity by developing cost-effective alternative water sources and alternative technologies/methods of treatment of these alternative water sources.
- Improving the environmental and public health costs/risks of California's electricity by providing solutions that reduce or eliminate the water-related impacts of electricity generation in California.

**Proposed Outcomes:**

1. Provide biofouling control and plant performance strategies.
2. Provide cost-effective wastewater treatment strategies.
3. Provide cooling water treatment and reuse strategies.
4. Conduct a Tailored Collaboration entitled "Degraded Water Study" to assess the use of degraded water sources within California in lieu of potable sources for closed-loop cooling of new power generation projects.
5. Conduct a Tailored Collaboration entitled "Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Technologies" for evaluation of the opportunities to implement lower water use options for power plant cooling in California.

**Actual Outcomes:**

1. Biofouling control.
  - A preliminary report was published on evaluation of non-toxic biofouling technologies.
  - A report was published on follow-up bench-scale tests and power plant slipstream evaluation of non-toxic biofouling technologies.
  - The 10<sup>th</sup> International Zebra Mussel Conference was cosponsored by EPRI.

- Research was conducted on controlling the biofouling of heat exchangers and cooling systems using new chemical and nonchemical macrofouling control technologies—in preparation for publication in 2001 of the *Revised Guidelines for Macrofouling Control Technology*.
2. Wastewater treatment.
    - A report - *Improvement of Plants for Selenium and Heavy Metal Phytoremediation Through Genetic Engineering (TR-114219)* - was published on the successful use of genetically engineered plants with superior capabilities for the phytoremediation of heavy metals such as selenium, molybdenum, cadmium, and tungsten.
    - The use of iron-coated sand was demonstrated for reducing solid waste volumes by orders of magnitude relative to iron co-precipitation, the current industry standard.
    - An assessment report, field test report, and guidelines were published for treating water using plant impounds in which toxic substances precipitate in holding ponds.
    - A report - *The San Francisco Bay Constructed Wetland Treatment System: The Use of Constructed Wetland Treatment Systems for the Removal of Toxic Trace Elements from Electric Utility Wastewater: Role of Vegetation (1000269)* - was published on research conducted at the Chevron constructed wetland treatment system on San Francisco Bay on the role of wetland plants in the volatilization of selenium and other toxic trace elements.
    - Research was conducted on wastewater treatment for removal of nitrogen compounds—in preparation for possible publication in 2001 of the *Guidelines for Wastewater Treatment for Removal of Nitrogen Compounds*.
  3. Cooling water treatment and reuse.
    - Results were published on the first pilot study of alternative biocide compounds for control of microfouling and macrofouling in cooling towers.
    - Case studies were conducted on the recycling and reuse of power plant water and wastewater to help reduce the cost and environmental consequences of water purchase, use, and discharge—in preparation of publication in 2001 of new guidelines.
  4. A report on the use of degraded water for power plant cooling was delivered in 2002. See separate write-up in this annual report under the title “Degraded or Reclaimed Power Plant Cooling Water”.
  5. A report evaluating the costs, design impacts, effects on generation capacity, and R&D needs for applying wet, dry, hybrid wet/dry, and alternative cooling systems for power generation applications in California was delivered in 2002. See separate write-up in this annual report under the title “Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Strategies”.

**Project Status:**

The Commission’s participation in this target ended December 31, 2000. The tailored collaboratives have been completed.

## Formation of NO<sub>x</sub> in Industrial Gas Burners & Gas

**Contract #:** 500-97-013 **Project #:** 9

**Contractor:** Regents - University of California

**Subcontractors:** University of California, Irvine : Combustion Lab : Scott Samuelsen

**Project Amount:** \$335,000

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

**Commission Contract Manager:** Matthew Layton (916) 654-3868

**Status:** Completed

### Project Description:

The purpose of this project was to develop technologies (and associated scientific and applications-oriented knowledge) to attain and maintain energy-efficient operation of natural gas industrial burners and stationary gas turbines with ultra-low emissions of nitrogen oxides (NO<sub>x</sub>). The core component of this project will be a closed-loop combustion control with advanced sensors, including field applications applied to industrial burners and boilers. The high temperature and boiler elements of this project, funded by Southern California Gas, Maxon and Coen, involve laboratory field testing and other technology transfer activities that interact synergistically with the core component.

Low emissions technologies are driving the development of new generation stationary power sources. The next generation industrial burners and stationary gas turbine combustors will be required to maintain extremely low levels of nitrogen oxides (NO<sub>x</sub>) and carbon monoxide (CO) emissions, previously thought unattainable. Current state-of-the-art is to use back-end clean up of the exhaust stream with selective catalytic reduction (SCR) or a similar technique. This method, although effective, is costly. Alternatively, burner and gas turbine combustor manufacturers are striving to reduce the pollutants at the source by adopting a lean-premixed or partially-premixed fuel and air strategy the challenge with lean premixed systems is that CO can increase and stability can decrease along with the reduction in NO<sub>x</sub>.

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

- Improving environmental and public health costs/risk of California's electricity by maintaining the energy efficiency and ultra-low emissions achieved in natural gas industrial burners and stationary gas turbines.

### Proposed Outcomes:

1. Further develop the active control system on a boiler burner (the first demonstration occurred through the CIEE core program).
2. Proof-of-concept of the active control on a gas turbine, both applications targeting the energy/electrical production market. The core component is a closed loop combustion control with advanced sensors, including demonstrations applied to industrial burners and gas turbines.
3. Identify fast feedback sensors.
4. Determine the suitability of these fast sensors for industrial burners and gas turbine applications.
5. Upgrade the active control software for ease-of-use and fast feedback capability.
6. Refine the use of the fast sensors and new software on industrial burners.
7. Demonstrate the fast sensors and new software on a gas turbine combustor.
8. Transition the experimental results to the combustion community.

**Actual Outcomes:**

A comprehensive active control strategy was successfully demonstrated for industrial gas burners and stationary gas turbines during this one-year project.

1. The fast sensors that were investigated and selected for trials were fiber optic collection of reaction chemiluminescence, an acoustic microphone, and a piezoelectric, dynamic-pressure sensor.
2. The active control computer system consisted of commercial software and hardware (National Instruments LabView and data acquisition boards) in conjunction with simple optimization techniques.
3. Control of the combustion processes was achieved using mass flow controllers to optimize the fuel injection and airflow at different operating conditions.
4. A second-generation active control system using fast sensors was demonstrated on two different sized industrial burner systems and a gas turbine combustor.
5. Transition of the results to the combustion community occurred via three presentations of the project results at two different combustion conferences and through personal interaction with industrial burner and gas turbine manufactures at the conferences.

**Project Status:**

The project has been completed.

The successes of this research are encouraging and timely for the electric industry in California. Central station and small, distributed generators will compete in the deregulated electricity market, which could mean constant cycling of firing rate while still complying with some of the strictest air pollution regulations in the country.

**Groundwater and Combustion By-Products Management - Target 97**

**Contract #:** 100-98-001 **Project #:** 21

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

**Subcontractors:** Diversified Program : Ishwar Mururka : Stephen D. Mueller : American Electric Power : Battelle Northwest Laboratories : META Environmental, Inc. : Natural Resource Technology, Inc. : Ohio Edison Company : Science & Technology Management, Inc. : Southern Company Services, Inc. : Tennessee Valley Authority : Tetra Tech, Inc. : University of North Dakota : Wisconsin Electric Power Company

**Project Amount:** \$312,000

**Match Amount:** \$2,387,775

**Contractor Project Manager:** Ken Ladwig (262) 641-8817

**Commission Contract Manager:** Thomas Tanton (916) 654-4930

**Status:** Completed

**Project Description:**

The purpose of this project is to deliver R&D results on leaching, attenuation, and fate of metals from combustion by-products disposal facilities to strengthen the basis for cost-effective regulations. Leaks and releases of fuel oils at power plants have resulted in contamination of subsurface soils and groundwater, requiring innovative approaches for remediation. Similarly, the storage of coal on land has resulted in the generation of leachates containing metals and acidity which are subject to surface and subsurface migration. This EPRI target also produces innovative methods for managing wastes and restoring soils and groundwater contaminated by sources other than power plant by-products. Databases and fate and transport software will be developed or enhanced to enable members to cost-effectively manage contaminated sites while protecting the surrounding environment.

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

- Improving the energy cost/value of California's electricity by determining cost-effective methods for remediating contaminated land and groundwater.
- Improving the environmental and public health costs/risks of California's electricity by effectively cleaning up the environment, thereby reducing human and ecological exposure to chemical contaminants.

**Proposed Outcomes:**

1. Provide scientific and engineering knowledge (software, information, manuals, and improved insights) for the management of chemicals in disposal sites, landfills, impoundments, and power plant storage facilities.
2. Provide characterization and remediation methods, information, and tools to improve soil and groundwater quality.
3. Design liners and barriers for effective groundwater protection.
4. Develop fate and transport analysis tools to support removal of contamination from groundwater.

**Actual Outcomes:**

1. Management of chemicals.
  - A report was published on the co-management of mill rejects at coal-fired power plants.
  - Proceedings were published from the 13th International Symposium on Use and Management of Coal Combustion Products.

2. Improvement of soil and groundwater quality.
  - Version 2.5 was released of the MANAGES database management system for the storage, analysis, and reporting of water quality data.
  - A report was published on groundwater quality at power plants in West Virginia.
  - A report was published on re-vegetation of a co-managed utility waste disposal area.
  - A report was published on restoration of eroded land using coal fly ash and biosolids.
  - A report was published on utilization of coal combustion by-products in agricultural and land reclamation.
  - A report was published on land application uses for dry flue gas desulfurization by-products.
  - Findings were published of an evaluation of an Ecolotree CAP for closure of coal ash disposal sites.
  - A report was published on the environmental distribution of petroleum hydrocarbons at a utility service center.

**Project Status:**

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

## Habitat and Species Protection

**Contract #:** 500-97-012 **Project #:** 5

**Contractor:** Edison Technology Solutions/Southern California Edison

**Subcontractors:** Electric Power Research Institute (EPRI) : Ed Almanza and Associates : University of California, Irvine : Premier Temporary Service : BioResource Consultants : Positive Systems : Applied Biomathematics, Inc.

**Project Amount:** \$525,000

**Contractor Project Manager:** Daniel Pearson (626) 302-9562

**Commission Contract Manager:** Marc Sazaki (916) 654-5061

**Status:** Completed

### Project Description:

The goal of this project was to minimize raptor mortality (and resulting electric power disruptions) associated with power lines by identifying where and why this mortality occurs and then developing recommendations to minimize these impacts. Research was also conducted to determine methods for minimizing the impacts of power facility construction on sensitive species and habitats.

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

- Improving environmental and public health costs/risk of California's electricity by developing methods to minimize the environmental impact of power facilities on sensitive species and habitats.
- Improving the reliability/quality of California's electricity by reducing bird-related power outages.

### Proposed Outcomes:

1. Reduce raptor mortalities caused by electrocution at power lines and power outages associated with such instances system-wide. Consequently, raptors would be protected and power line system reliability would be improved.
2. Develop protocols to characterize and monitor critical California habitat types to avoid or minimize impacts through multiple species habitat conservation research and habitat evaluation. Given the development of these protocols, fewer habitat and species issues should arise.
3. Apply developed models in future planning efforts to allow for more comprehensive validation of new habitat and species protection approaches.

### Actual Outcomes:

1. Produced a series of reports that present reliable and cost-effective methods for identifying areas with recurring raptor electrocution problems. Appropriate mitigation actions can be applied in problem areas where found.
2. A series of reports have been completed that describe advanced aerial mapping techniques that can be used for characterization of plant species composition and abundance in sensitive habitats that may be used by a multitude of wildlife species, such as the legally protected California gnatcatcher. In addition, models that estimate extinction rates for threatened and endangered species are described, including the California gnatcatcher and the desert tortoise. These methods are available for use to minimize potential impacts associated with electricity development in California.
3. The reports are available on the Commission's Web site.

### Project Status:

The project has been completed.

**Plant Multimedia Toxics Characterization - Target 107**

**Contract #:** 100-98-001 **Project #:** 22

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

**Subcontractors:** Carnegie Mellon University : CH2M Hill, Inc. : Fossil Energy Research Corp. : METCO Environmental, Inc. : Mostardi-Platt Associates, Inc. : Quality Associates Int'l Canada Ltd. : Radian International LLC : RMB Consulting and Research, Inc. : Tennessee Valley Authority : TRW, Inc. : United States Geological Survey : University of Louisville : University of North Dakota : Bevilacqua-Knight, Inc.

**Project Amount:** \$276,000

**Match Amount:** \$3,849,810

**Contractor Project Manager:** Babu Nott (650) 855-7946

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

**Project Description:**

The purpose of this project is to measure and characterize potentially toxic substances in air, water, and solid waste streams emanating from electric power plants. This effort is critical for managing toxic emissions and discharges in an environmentally acceptable and cost-effective manner. EPRI's PISCES (Power Plant Integrated Systems: Chemical Emissions Studies) project was launched in 1988 to collect and analyze power plant trace substances data for multimedia discharge/emissions implications. PISCES data also enable meaningful analysis of the health risks posed by power generation emissions and discharges. To date, the data generated by the PISCES project have been provided to the U.S. EPA (in EPRI's Synthesis Report) and used in EPA's report to Congress on hazardous air pollutants. The tools provided in this target can be utilized to assess opportunities for pollution prevention, to evaluate the impact of alternative strategies, and to establish benchmarks for pollutant inventory and tracking. In addition, work will be initiated to address material balance studies involving such key elements as carbon, sulfur, and nitrogen that are associated with such issues as global climate change, acid deposition, and coastal water nitrification.

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

1. Improving the environmental and public health costs/risks of California's electricity by providing:
  - Meaningful analysis of the health risks posed by power plant emissions and discharges.
  - Assessment of opportunities for pollution prevention and of impact of alternative strategies.
  - Establishment of benchmarks for pollutant inventory and tracking.
  - Research results on global climate change, acid deposition, and coastal water nitrification.

**Proposed Outcomes:**

1. Improve the PISCES modeling capabilities by conducting characterization field tests to accurately measure multimedia emissions, upgrading the database, and expanding the chemical assessment model.
2. Provide accurate characterization data on solids (including fuels, reagents, by-products, and solid wastes) to support cost-effective, environmentally acceptable power plant operation and management.

3. Determine more accurate and sensitive methods for analyzing organics such as dioxins to avoid “non-detects,” especially if the thresholds for the release of these chemicals are significantly lowered (for example, for TRI reporting).

**Actual Outcomes:**

1. Improve PISCES modeling capabilities.
2. PISCES: Power Plant Chemical Assessment Model, Version 3.03 software was developed.
3. Organizations were surveyed to develop a Version 4.0 of the PISCES model to improve usability and speed, and incorporate enhancements for the Toxics Release Inventory.
4. A comprehensive characterization was conducted of wastewater at a zero-discharge fossil-fuel-fired power plant, and a water characterization field study report was published.
5. The Fourth International Conference on Managing Hazardous Air Pollutants was held with EPRI sponsorship, and the proceedings of the conference was published.
6. A scoping study was conducted, and a report published on the American Eel (*Anguilla rostrata*).
7. Advanced methods were developed for sampling and analyzing different species of trace metals such as mercury and nickel. Methods were developed for measuring nickel subsulfide emissions from oil-fired power plants, nickel speciation measurements at oil-fired power plants, and mercury speciation stack sampling.
8. A study was conducted of toxic emissions from a gasification-combined cycle (GCC) power plant.

**Project Status:**

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

## Risk Evaluation of Chemicals Used in the Photovoltaic Industry in California

**Contract #:** 100-98-001 **Project #:** 57

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

**Project Amount:** \$27,250

**Match Amount:** \$27,250

**Contractor Project Manager:** Ken Ladwig (262) 641-8817

**Commission Contract Manager:** Laurie ten Hope (916) 654-4637

**Status:** Completed

### Project Description:

The purpose of this project was to collect information on potential environmental impacts associated with chemicals used in the California photovoltaic (PV) industry. This information will be used to determine directions for future research activities. In particular, the Commission is interested in pursuing those PV cell technologies with the least potential for toxic chemical use and associated risks. The objectives of the project are to identify chemicals used in PV cells and their potential for release to the environment, particularly groundwater and to identify existing and emerging PV technologies with relatively lower toxic risk compared to other cell types.

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

- Improving the environment and the public health costs/risks of California's electricity by identifying the potential for chemicals used in PV cells to be released in the environment, particularly to groundwater, thereby helping reduce human and ecological exposures to these chemical contaminants.

### Proposed Outcomes:

1. Review literature describing potential environmental issues associated with the manufacture and disposal of PV cells. Summarize information on the following topics:
  - The estimated number of PV cells produced and in use, common applications, life-span, and disposal practices.
  - Manufacturing processes used in the production of PV cells, the chemicals used in the manufacturing process and their potential for release.
  - Disposal and recycling of used PV cells.
2. Perform a qualitative assessment to identify existing and emerging PV cell technologies with relatively lower toxic risks compared to other cell types.
3. Publish a short report describing the above efforts.

### Actual Outcome:

1. The above tasks were completed successfully. A report describing results was prepared and submitted for publication in December 2001.

### Project Status:

This project has been completed.

**Section 316(a) and (b) Fish Protection Issues - Target 44**

**Contract #:** 100-98-001 **Project #:** 15

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

**Subcontractors:** Alden Research Laboratory, Inc. : Applied Biomathematics, Inc. : Duke Energy Corporation : EA Engineering Science and Technology : Langhei Ecology LLC : Lockheed Martin Energy Systems, Inc. : Tennessee Valley Authority : Tetra Tech, Inc. : Kenneth Rose

**Project Amount:** \$525,400

**Match Amount:** \$5,696,834

**Contractor Project Manager:** Doug Dixon (804) 642-1025

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

**Project Description:**

The purpose of this project is to provide methods for studying fish entrainment and impingement mortality and generate results for fish population predictions that will be used to address biological community and biodiversity risks associated with power plant and industrial facilities operations. The protection of single fish species and aquatic communities is a primary focus of water permitting for coal, oil, gas, and nuclear power plants and industrial facilities under Clean Water Act Section 316(a) (heated and chlorinated cooling water discharges), and Section 316(b) (entrainment into intakes and impingement on intake screens). This EPRI target will support cost-effective fish protection and facility operational decision-making.

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

- Improving the environment costs/risks of California’s electricity by studying how to reduce the negative effects of thermal power plants (using once-through cooling) on aquatic resources in freshwater and marine environments.
- Improving the public health costs/risks of California’s electricity by protecting fish in cost effective ways to minimize environmental impacts on aquatic environments that impact humans.

**Proposed Outcomes:**

1. Provide California with effective “best technology available” (BTA) engineering methods for cooling system intakes.
2. Provide objective science and engineering to the California energy enterprise debate in water use impacts.
3. Develop accurate ecological risk assessment tools to assess the effects of power plant operation on individual fish and the risks to aquatic communities for cost-effective fish protection options.
4. Develop Aquatic Ecosystem Evaluation Methods, Ecological Risk Assessment Frameworks, Compensation Mechanisms in Fish Populations (CompMech), and Thermal Discharge Risk Analyses.

**Actual Outcomes:**

1. Intake fish protection system assessments.
  - A report was produced summarizing a review of fish protection technologies at cooling water intakes.
  - Research was conducted and a report produced on the effectiveness of bar racks and louvers for preventing passage of fish through turbines at hydroelectric projects.

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- Guidelines were published for selecting technologies appropriate for “best technology available” (BTA) analysis based on site-specific factors such as plant design, representative fish species present, and others. The guidelines will help California facilities determine their own best BTA options prior to construction.
2. Objective science and engineering on water use impacts.
    - Proceedings were published of a technical workshop on the Clean Water Act Section 316(b).
    - A report was published on methods for evaluating nursery and spawning habits.
  3. Ecological risk assessment methods.
    - New information was developed on ecological risk endpoints for abundant species. This project will provide a method for resource agencies to benchmark the risk of any impact on various species.
    - An ecological risk case study was conducted on Hudson River striped bass, applying the ecological risk endpoints method.
    - A report was published on performing a human health and ecological risk assessment using the RIVRISK software program.
    - A report was published on using water approach velocity as a screening tool.
    - A report was published on adapting risk analysis processes to 316(b) Tier 3 Assessments.
    - A database was compiled on entrainment survival for fish and other aquatic species.
  4. Aquatic ecosystem evaluation methods.
    - A catalog was published on assessment methods for evaluating the effects of power plant operations on aquatic communities.
    - A report was published on applying biocriteria as a concept, approach, and tool for assessing impacts of entrainment and impingement under 316(b).

### **Project Status:**

The Commission’s participation in this target ended December 31, 2000.

**Targets: 87.0/48 Hydropower Operations, Relicensing and Environmental Issues**

**Contract #:** 100-98-001 **Project #:** 17

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

**Subcontractors:** B.C. Hydro International Ltd. : HCI Publications : Iris Power Engineering, Inc. : Kearns & West, Inc. : EA Engineering Science and Technology : Science & Technology Management, Inc. : Lang, Railsback & Associates : Lockheed Martin Energy Systems, Inc.

**Project Amount:** \$100,200

**Match Amount:** \$1,391,292

**Contractor Project Manager:** Norris Hirota (650) 855-2084

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

**Project Description:**

The purpose of this project is to address the challenges facing the hydroelectric industry that come in the areas of Federal Energy Regulatory Commission (FERC) relicensing and environmental mitigation. Balancing the protection of fish and wildlife resources with multiple demands for water use can be optimized by utilizing credible scientific information, tools, and methods. The management of hydro project decommissioning, including impoundment sediment management (characterization, removal, and disposal), dam removal, and ecosystem restoration are complex technical issues for which little background science exists. This EPRI tiered target offers cost-effective solutions to address critical relicensing, environmental, and public issues related to the hydro industry, by utilizing the world-renowned expertise of EPRI scientists and engineers, forums for sharing information and capitalizing on the lessons learned by others, and leveraged development of solutions to common problems.

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

- Improving the reliability/quality of California's electricity by compiling expert knowledge on the best practices for optimizing hydro plant operations and performance to enhance grid reliability.
- Improving the energy cost/value of California's electricity by helping to minimize the cost of hydropower while protecting the environment.
- Improving the environmental costs/risks of California's electricity by providing expert knowledge on addressing multi-stakeholder relicensing issues and by studying how best to manage entire watersheds containing hydroelectric development, rather than managing hydro projects individually.

**Proposed Outcomes:**

1. Improve the relicensing process to achieve results acceptable to all stakeholders at minimum cost to stakeholders by providing information on relicensing best practices for the hydropower industry.
2. Provide information on of worldwide technological developments relevant to the hydropower business.

3. Improve fish protection methods by providing scientific information, techniques, and guidance based on state-of-the-art and emerging methods for instream flow management.
4. Provide assessment methods for more accurately evaluating the effects of turbine entrainment and mortality on fish populations.
5. Provide information and tools for determining cost-effective upstream and downstream fish passage and protection needs for migratory and nonmigratory fish.
6. Provide information for water resources management to optimize power production while complying with environmental protection requirements.
7. Offer a cost-effective approach for site-specific environmental data gathering and ecosystem research needs while providing future communication links with the environmental management, regulatory, and research community.

**Actual Outcomes:**

1. Best practices.
  - A *Preferred Practices Guidebook* was developed that outlines effective hydro relicensing practices.
  - The National Relicensing Group (NRG), sponsored by EPRI, developed a manual on best practices for hydropower relicensing entitled *Hydro Relicensing Forum: Relicensing Strategies (1000737)*.
  - The NRG met three times in 2000 to discuss issues related to relicensing and to develop the best practices manual.
2. New information was provided in several reports for optimizing hydropower operations through rehabilitation, upgrading, condition monitoring, and life extension of hydropower facilities. They are *Hydro Life Extension Modernization Guide: Volume 1: Overall Process (TR-112350-V1)*, *Hydro Life Extension Modernization Guides: Volume 2: Hydromechanical Equipment (TR-112350-V2)*, *Steel Penstock Coating and Lining Rehabilitation: A Hydropower Technology Roundup Report, Volume 3 (TR-113584-V3)*, and *Hydro Life Extension Modernization Guide: Volume 7 - Protection and Control (TR-112350-V7)*.
3. Instream flow management.
  - EPRI's Individual-Based Instream Trout Model was developed and successfully tested.
  - A review and evaluation of state-of-the-art instream flow assessment methods was conducted, compiled in a draft report, peer-reviewed, and published in a final report.
4. Assessment methods for turbine entrainment and mortality.
  - An improved modeling approach was developed for studying fish behavior and impacts of hydro systems on fish.
5. Fish passage and protection needs.
  - An evaluation was made of bar racks and louvers for preventing turbine entrainment and guiding fish to bypasses. Tests were conducted on lake sturgeon, shiners, walleye, smallmouth bass, and American eels, and results published in a report.
  - Two symposia were held and papers published on passage and protection of catadromous eels and green sturgeon.
6. New information was presented on the extent and severity of reservoir sedimentation problems in the United States and current practices to mitigate or prevent sediment-related problems, including a case study at a California hydroelectric project.
7. Support was provided for graduate research fellowships in Ecology and Hydrology.

**Project Status:**

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

## Trenchless Burial Equipment

**Contract #:** 500-97-011 **Project #:** 1

**Contractor:** San Diego Gas and Electric Company

**Project Amount:** \$130,000

**Contractor Project Manager:** Tammie Candelario (415) 973-8873

**Commission Contract Manager:** Ellen Townsend-Smith (916) 654-4170

**Status:** Completed

### Project Description:

The purpose of this project was to develop three time- and cost-saving technologies that will allow utilities to construct and maintain underground electrical distribution facilities. Remote sensing and detection equipment would be developed that improves the utilities' ability to service existing underground facilities and improves the current underground tunnel boring technologies.

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

- Improving the reliability/quality of California's electricity by developing technologies that will allow utilities to reduce power outages and minimize the impact of such outages when they occur.

### Proposed Outcomes:

1. Develop a wireless fault indicator which would allow SDG&E crews to locate cable faults with a hand-held radio device rather than the conventional method of physically opening vaults to inspect fault switches.
2. Develop and demonstrate SafeNav, a device for detecting and avoiding underground obstacles before collision during boring.
3. Develop a digital imaging system designed to improve the productivity and safety during inspection and inventory of underground distribution facilities.

### Actual Outcomes:

1. The Radio Based Fault Indicator (RBFi), a wireless radio-based fault indicator technology would allow crews to locate underground cable faults with a hand-held radio device, instead of the conventional manual way by physically opening vaults to inspect fault switches. A RBFi unit is installed within a manhole or underground vault. During a power outage, utility personnel drive to the vicinity of the suspected fault, and poll (query) the Fault Indicator unit with a hand held reader that displays the indicates the condition of the fault. In early field-testing, 40 units were installed and tested by field crews at SDG&E. Several of the units failed because of moisture (or other contamination) intrusion in the battery case. Although field-testing demonstrated that the concept is technically valid, financial constraints prevent the contractor from pursuing design modifications. These issues are not deemed insurmountable and further funding is under consideration because of anticipated benefits in the areas of labor reduction, timesaving and improved system reliability, and personnel safety by avoiding having to physically open vaults.
2. SafeNav, an underground horizontal drilling technology, detects underground obstacles and notifies the driller by alarms when obstructions are located within the bore path. SafeNav is designed to minimize damage to existing underground utilities and lower the occurrence of outages and associated safety hazards. Under this project, preliminary field-testing was completed and necessary design modifications developed. The results of these tests suggest that SafeNav could improve safety, reduced drilling costs, result in faster installation time, and less disruption to consumers. If successfully commercialized,

- anticipated savings from the system are estimated to exceed \$300,000 annually, when comparing actual horizontal drilling to open trenching costs in a typical fiscal year.
3. A Digital Inspection System (DIS) would allow access to underground facilities through an existing orifice on a manhole or handhole cover. A probe is placed into the vault to image the surrounding walls thus, mapping the vault configuration. The Digital Imaging Systems enables one person to perform the inspection, resulting in substantial savings in labor costs and reduced exposure to hazardous conditions. In conventional methods, entry to subsurface structures for inspection requires elaborate procedures to render the spaces safe. This includes water-pumping and atmosphere purging, involving crews of at least three people. Under this project, a design analysis was completed to define parameters for hardware selection. Bench scale testing identified a number of engineering issues including maintaining spatial orientation and visual resolution. These issues will be addressed in the next phase of the project.

**Project Status:**

The project has been completed.

## Water Quality Criteria and Toxics in Aquatic Environments - Target 43

**Contract #:** 100-98-001 **Project #:** 24

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

**Subcontractors:** Great Lakes Environmental Center : University of Wisconsin : University of Trent : Tetra Tech, Inc. : Fresh Water Institute : Water Environment Research Foundation : EA Engineering Science and Technology : United States Geological Survey : Allegheny Power : Frontier Geosciences : Battelle Northwest Laboratories : ICF Consulting

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

**Match Amount:** \$1,541,861

**Contractor Project Manager:** John Goodrich-Mahoney (650) 855-5256

**Commission Contract Manager:** Joe O'Hagan (916) 653-1651

**Status:** Completed

### Project Description:

The purpose of this project is to provide the CEC with information and tools to help improve the scientific basis for California water quality criteria. The products of this target may also facilitate the use of site-specific conditions and new data to assess the impacts of toxic chemicals in California's aquatic environments. Findings can be applied directly to meet specific technical challenges. They are also useful to the regulatory and scientific communities, helping to inform ongoing deliberations and to increase understanding of critical issues.

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

- Improving the environmental and public health costs/risks of California's electricity by providing tools that lead to more precise estimates of human health and ecological risks and establish the basis for more cost-effective regulations and compliance methods.

### Proposed Outcomes:

1. Upgrade the Dynamic Mercury Cycling Model, which models mercury deposition, transformation, and bioaccumulation in lakes.
2. Develop models for assessing metal toxicity on a site-specific basis.
3. Develop a guidance document for determining a site-specific criterion for selenium.
4. Evaluate and improve risk assessment methodologies for water quality criteria.
5. Provide information on the health risks of arsenic.
6. Improve the accuracy of criteria for contaminated sediments.
7. Assess the emerging field of biocriteria and its application to water bodies.
8. Explore the application of persistent bioaccumulative toxics (PBTs) to metals and inorganic metal compounds.

### Actual Outcomes:

1. An upgraded version of the Dynamic Mercury Cycling Model - *Dynamic Mercury Cycling Model Version 1.1 (1001114)* – was produced. The model will be helpful in assessing total maximum daily load of mercury in several large California lakes.
2. A biotic ligand model (BLM) for copper was developed. This model can be used to develop site-specific metal toxicity in California water bodies.
3. A technical workshop was held to develop a guidance document for determining a site-specific criterion for selenium.
4. Risk assessment methodologies.
  - A report was published evaluating of current Federal risk-assessment methodologies.
  - A user's guide to RIVRISK, Version 5.0, - *User's Guide for RIVRISK Version 5.0: A Model to Assess Potential Human Health and Ecological Risks from Power Plant*

*and Industrial Facility Releases to Rivers (1000733)* - was published. This model can be used to assess human health and ecological risks associated with industrial and power plant chemical and thermal releases to rivers.

- EPRI prepared technical comments on EPA's proposed rule on human health methodology.
5. A peer-reviewed white paper was published summarizing EPRI research conducted over several years on the health risks of arsenic. EPRI also prepared technical comments on the EPA proposed rule on arsenic.
  6. Contaminated sediments.
    - A report - *Overview and Evaluation of the U.S. Environmental Protection Agency's Sediment Quality and Sediment Criteria Program (1000437)* - was published providing a critical assessment and review of EPA activities and research on contaminated sediments.
    - Proceedings were published of an EPRI workshop on sediment guidance and regulation.
  7. Proceedings - *Proceedings of the 1999 Workshop on Biocriteria: Framework and Implementation (1000435)* - were published of an EPRI-hosted national workshop on biocriteria.
  8. A workshop - *Experts Workshop: Review of the State-of-the-Science Regarding PBT Concepts and Metals and Metal Compounds (WM-114920)* - was held to explore the state-of-the-science concerning application of PBTs to metals and inorganic metal compounds, principally mercury and lead.

**Project Status:**

This project has been completed.

## **ENV Projects Completed in 1999**

**Avian Powerline Interaction Committee**

**Contract #:** 500-97-010 **Project #:** 6

**Contractor:** Pacific Gas and Electric Company

**Project Amount:** \$40,000

**Contractor Project Manager:** Sheila Byrne (925) 866-5987

**Commission Contract Manager:** Dick Anderson (805) 821-3715

**Status:** Completed

**Project Description:**

This project developed a course on reducing bird electrocutions and electric power disruptions associated with bird collisions with powerlines as part of PG&E's involvement in the Avian Powerline Interaction Committee (APLIC). The APLIC is an internationally recognized organization with approximately a dozen utilities, as well as the U.S. Fish and Wildlife Service and the Audubon Society as members. It is dedicated to developing methods to mitigate the impact of powerlines on birds. Bird collisions with powerlines result not only in transmission line outages, but also harms or kills rare and endangered species.

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

- Improving the reliability/quality of California's electricity by providing interested parties with current technical information on how to reduce bird collisions with powerlines, thereby lessening or preventing power outages resulting from these collisions.
- Improving environmental and public health costs/risk of California's electricity by providing information to reduce bird mortality associated with powerline collisions.

**Proposed Outcome:**

Develop a course on reducing bird electrocutions and electric power-disruptions associated with bird collisions with powerlines as part of PG&E's involvement in the Avian Powerline Interaction Committee (APLIC).

**Actual Outcomes:**

The short course, entitled, "Reducing Bird Collisions and Electrocutions," was held in May of 1998 at PG&E's Livermore Training Center. The short course provided an excellent forum for information exchange regarding causes and solutions for many types of bird electrocution and collision fatalities and associated power outages. Measures presented to reduce bird electrocutions included special insulation for potential electrocuting contact points and using an electrocution-proof configuration design in the construction of new powerlines. Measures discussed to reduce collisions included avoiding high bird use areas in siting of new powerlines and attaching various shaped devices (bird flight diverters) in order to alert birds to the hazard and allow them to avoid the line. Information was distributed to course attendees that will allow them to evaluate existing structures and recommend measures, as needed, to decrease adverse bird interactions with utility structures. The short course was well attended and received high marks by attendees.

**Project Status:**

The project has been completed.

**Regional Ambient Aerosol Study (RAAS)**

**Contract #:** 500-97-010 **Project #:** 4

**Contractor:** Pacific Gas and Electric Company

**Subcontractors:** Atmospheric & Environmental Research, Inc. : Douglas Becker : Kelly Managerial Service

**Project Amount:** \$399,000

**Contractor Project Manager:** Sam Altshuler (925) 866-5879

**Commission Contract Manager:** Guido Franco (916) 654-3940

**Status:** Completed

**Project Description:**

This project allowed PG&E to continue providing technical expertise to the California Regional PM10/PM2.5 Air Quality Study (particulate matter less than 10 and 2.5 micrometer  $\mu\text{m}$  size, respectively), a multi-agency study headed by the California Air Resources Board (CARB). Particulate matter (PM) smaller than approximately 2.5 micrometer ( $\mu\text{m}$ ) tends to result from combustion processes including electric generating technologies, while PM larger than 2.5  $\mu\text{m}$  results from sources such as windblown dust or seasalt. Significantly, it is PM2.5 that health experts consider most harmful to humans, because particles of this size can penetrate the body's natural defense mechanisms and reach most deeply into the lungs. For example, a recent comprehensive study has found that an increase of 1 microgram per cubic meter in particulates results in about 4 to 8 more deaths per 100,000 live births (infant mortality).

The San Joaquin Valley is not compliant with the State ambient PM air quality standard of 50-micrograms/cubic meter. Central California (including San Francisco and Sacramento) is not compliant with the federal ambient PM air quality standard of 150-micrograms/cubic meter. Therefore, compliance with the particulate matter standard, the ultimate objective of the large research program headed by ARB, will result in significant health benefits in California.

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

- Improving environmental and public health costs/risk of California's electricity by improving the scientific understanding of the PM problem in Northern California. It emphasizes the quantification of emissions, the chemistry and physics involved in the transport of PM, the formation and removal of PM and characterization of the meteorological conditions conducive to high concentrations.

**Proposed Outcomes:**

1. Allow PG&E to continue providing technical expertise to the California Regional PM10/PM2.5 Air Quality Study.
2. PG&E involvement in technical and policy discussions.
3. Revise and provide comments on technical documents prepared for the study.
4. Participate in research activities culminating in technical papers presented at conferences publication of technical papers.
5. Document a field research program conducted in 1995.
6. Prepare conceptual models for ozone and particulate matter formation in the central California region.
7. Prepare specific analyses such as the role of volatile organic compounds (VOC) in the formation of secondary ammonium nitrate in the San Joaquin Valley.

**Actual Outcomes:**

1. Participated in the design and planning of the Central California Ozone Study (CCOS) as it evolved.
2. Identified the possibility of long-range aloft transport and the need for a mesoscale (regional) domain model that includes upwind metropolitan areas such as the San Francisco Bay Area, Monterey, and San Luis Obispo.
3. Team member Dr. Paul Solomon co-authored and published a paper, Modeling the Effects of Emission changes on PM<sub>2.5</sub> Using the UAM-AERO Model in the South Coast Air Basin, in the Proceedings of the PM<sub>2.5</sub> Conference in January 1998.
4. Two articles written as part of the 1995 Integrated Monitoring Study have been published in a special issue of Atmospheric Environment, a premier air pollution peer-reviewed publication.
5. The article Ozone Formation in the California San Joaquin Valley: A Critical Assessment of Modeling and Data Needs, authored by Pun et al, has been submitted and accepted for publication in the Journal of the Air and Wastes Management Association.
6. Developed a conceptual model for fall and winter PM concentrations in the San Joaquin Valley using the data gathered during the 1995 Integrated Monitoring Study. This model provides a better balance between meteorological and chemistry in the analyses of PM episodes than previously developed models, allowing for increased accuracy in modeling PM concentrations.
7. Developed a conceptual model, incorporating the physical dynamics and chemistry of O<sub>3</sub> formation in the San Joaquin Valley.
8. Developed and used a box model to investigate the response of PM nitrate to reductions in precursor emissions within the San Joaquin Valley.
9. Found that the formation of nitric acid and particulate nitrate is sensitive to oxidants and to volatile organic compound emissions during the fall and winter.

**Project Status:**

This project is expected to continue through 2003. The overall study headed by the CARB has produced a number of conclusions including:

1. The merits of detailed and complex analyses at fewer selected sites relative to less detailed measurements at more sites.
2. The role of fog in PM formation and removal.
3. The influence and regional extent of ammonium nitrate on wintertime PM formation.
4. The degree that PM studies in one or two urban areas can be translated to other urban areas in the Central California region.
5. The degree to which residential wood burning is an important contributor to ambient PM.

## **Transmission Line Bird Strike Monitor**

**Contract #:** 500-97-010 **Project #:** 5

**Contractor:** Pacific Gas and Electric Company

**Project Amount:** \$100,000

**Contractor Project Manager:** Sheila Byrne (925) 866-5987

**Commission Contract Manager:** Linda Spiegel (916) 654-4703

**Status:** Completed

### **Project Description:**

The purpose of this project was to develop an efficient and cost-effective system to detect electric power-disrupting bird collisions with powerlines using a wire-trip mechanism. This system is designed to provide power line owners with the tools necessary to identify the power lines responsible for multiple bird collisions, without spending excessive time or money for unreliable or labor intensive reconnaissance. Once the power lines with high number of bird strikes are identified, powerline owners can then initiate mitigation strategies to reduce collisions. The Bird Strike Monitor can be used by all utilities and applicable regulatory agencies to identify and mitigate power lines responsible for multiple bird collisions.

In locations that receive high use by migratory waterfowl, collisions with power lines can result in high bird mortalities, which is in violation of the Migratory Bird Treaty Act. There are numerous documented cases where listed species, such as the bald eagle and sandhill crane, have been killed as a result of collisions with power lines. Although collisions are frequent, they are often difficult to detect or are in remote locations. Current methods used to identify lines responsible for killing birds and to determine actual numbers of bird mortalities are labor intensive and unreliable. It is cost prohibitive to monitor the several thousand miles of power lines in the State and birds that have been electrocuted are often quickly removed by other wildlife before they can be detected. Furthermore, these bird collisions can cause expensive power outages or damage equipment. With the development of the Bird Strike Monitor, it may be possible to both decrease the number of bird-kills and power outages.

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

- Improving environmental and public health costs/risk of California's electricity by providing information to reduce bird mortality associated with powerline collisions.
- Improving the reliability/quality of California's electricity by reducing bird-related power outages.

### **Proposed Outcomes:**

- Develop an affordable, reliable and proven device to detect bird collisions with electrical transmission and distribution wires.
- Help identify locations along transmission and distribution lines with high incidence of bird collisions.
- Modify transmission and distribution lined to reduce collision risk.
- Help utilities comply with applicable laws such as the Migratory Bird Treaty Act, state and federal Endangered Species Acts, and the Bald Eagle Protection Act.
- Reduce the incidence of temporary power outages.
- Design specifications of the Bird Strike Monitor will be documented sufficiently for manufacture, once the proto-type has been deemed cost effective and reliable.

**Actual Outcomes:**

Results of tests on the Bird Strike Monitor and design specifications are due in March 2000. Copies of the final report will be available to interested parties. A final meeting will be scheduled to discuss the next steps that should be taken concerning the continued advancement of the Bird Strike Monitor.

**Project Status:**

The project has been completed.

## Wildlife Interactions with Electrical Distribution Facilities

**Contract #:** 500-97-010 **Project #:** 8

**Contractor:** Pacific Gas and Electric Company

**Subcontractors:** Colson and Associates

**Project Amount:** \$130,000

**Contractor Project Manager:** Mark Dedon (925) 866-5829

**Commission Contract Manager:** Rick York (916) 654-3945

**Status:** Completed

### Project Description:

The purpose of this project was to analyze products that reduce or prevent wildlife interactions, and resulting electrocutions and power outages, with powerlines and power facilities. Distribution line add-on insulation and perch deterrent products that were added to distribution line power poles were analyzed to evaluate their durability and effectiveness.

This research project also evaluated the applicability and effectiveness of a geographic information system (GIS) model that would allow Pacific Gas and Electric (PG&E) to plan future electrical facility upgrades to reduce wildlife electrocutions and associated power outages. The GIS model is designed so it can also help predict “high risk” areas so new distribution lines and existing distribution line upgrades and designed so wildlife electrocution-related power outages are minimized. The GIS model was also developed in response to a 1994 settlement agreement between PG&E and the U. S. Fish and Wildlife service that arose after citations were issued to PG&E for the electrocutions of several Swainson’s hawks, a State-protected species. Birds and other animals are the fourth leading cause of electric distribution outages in the PG&E system.

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

- Improving environmental and public health costs/risk of California’s electricity by improving current systems and technologies that prevent bird electrocutions caused by powerlines.
- Improving the reliability/quality of California’s electricity by reducing bird-related power outages.

### Proposed Outcomes:

1. Conduct research to evaluate the durability of specialized add-on insulation products and perch deterrent products installed in the field to reduce wildlife electrocutions and resulting outages. Based on preliminary laboratory tests conducted by PG&E during 1996-97, some insulation products are susceptible to degradation caused by various environmental factors such as moisture, sunlight, contaminants, etc. Some materials deteriorated quickly in laboratory tests and PG&E has recovered some products that have deteriorated in the field. This research was to examine the condition of various products installed in the field and installation procedures as appropriate.
2. Address the usefulness of the geographic information system (GIS) model that incorporates the PG&E electrical distribution network and predictable wildlife resources to reduce the risk for wildlife electrocutions/collisions and outages on selected circuits. The GIS model was developed by PG&E in 1997 to aid in predicting areas susceptible to wildlife interactions. Electric planners and engineers believe a GIS system could improve system reliability when used for planning new circuits or upgrading existing circuits.
3. Evaluate the GIS system in selected PG&E Divisions to obtain data on its usefulness. The merits of this system will be shared with other utilities to determine its applicability outside the PG&E service area.

**Actual Outcomes:**

1. Wildlife-Protective Devices.
  - Objective:
    - To better understand the expected life span of wildlife-protective devices in the field.
  - Outcomes:
    - Based on the limited sample of protective devices observed, approximately 15 percent showed a degree of degradation that is likely to reduce their performance.
    - Approximately 65 percent of the poles observed had wildlife protective devices that were not installed according to manufacturer recommendations or PG&E Engineering Standards. Installations were incomplete or improperly executed.
    - While PG&E cannot say that improper or incomplete installation practices or degrading devices are the reason wildlife-caused outages continue to trend up in most PG&E divisions, it is likely they result in providing a risk for future outages.
  
2. Geographical Information System (GIS).
  - Objective:
    - To implement the GIS developed in the pilot study throughout PG&E's service territory.
  - Outcome:
    - The GIS system is now being used for a selected PG&E service territory.
  - Objective:
    - Encourage use of the GIS by planners to better design new circuits in areas vulnerable to wildlife-caused outages.
  - Outcome:
    - The project benefits from the use of PG&E's Intranet Map Server with centralized data. PG&E distribution planners are gradually discovering its usefulness in the design of new circuits and upgrades to existing circuits.
    - Currently, GIS training is in high demand and user feedback is extremely positive.
  - Objective:
    - Develop a risk model that indicates "high risk" areas where birds are more vulnerable to electrocution within PG&E's service area.
  - Outcome:
    - The GIS provides the required risk model to comply with the PG&E/U.S. Fish and Wildlife Service settlement agreement.

**Project Status:**

This project has been completed.