Confirmation Number:

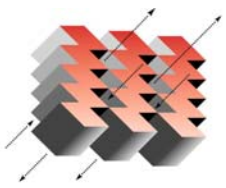
Statewide Retrocommissioning Program Proposal

Submitted by:
Portland Energy Conservation, Inc. (PECI) and
Architectural Energy Corporation (AEC)

Contact Person:
Phil Welker, Executive Director
PECI
1400 SW Fifth Avenue
Suite 700
Portland, OR 97201

503-595-4475
pwelker@peci.org

September 23, 2003



ARCHITECTURAL ENERGY
CORPORATION
Integrated Engineered Solutions

Table of Contents

Section I: Program Overview

A. Program Concept

The Statewide Retrocommissioning Program (Statewide RCx) is a unique energy efficiency effort aimed to achieve cost-effective peak energy and demand savings and establish a framework for a long-term, comprehensive retrocommissioning program in the State of California. The program is designed to expand retrocommissioning capabilities in California by directly addressing market barriers, as well as ensure persistence of benefits from retrocommissioning. In the program, these objectives are met through the development of retrocommissioning protocols, building operator and commissioning provider trainings, and buildings operation tracking systems. Furthermore, to effectively market retrocommissioning services, the program will leverage existing relationships among building owners, the utilities (PG&E, SCE and SDG&E), and local governments, including the City of San Francisco. The proposal team, Portland Energy Conservation, Inc. (PECI) and Architectural Energy Corporation (AEC), will bring together their extensive experience in program management and execution of commissioning projects to create a successful retrocommissioning program for California.

B. Program Rationale

Building commissioning is increasingly recognized as a cost-effective process to improve building performance, reduce energy use, and improve indoor air quality, occupant comfort and productivity. Over the past ten years, utilities in California and across the United States have been important supporters of the commissioning industry, and their support has led to significant energy savings. However, most buildings have never undergone a commissioning or quality assurance process, and are therefore likely performing well below their potential. In 1998, a study for the Department of Energy estimated that less than 0.03% of existing buildings were retrocommissioned each year.[1] Although that percentage has most likely increased since 1998, there are substantial energy saving opportunities through retrocommissioning existing buildings.

Retrocommissioning (RCx) applies a systematic process for improving and optimizing a building's operations and supporting those improvements with enhanced documentation and training. The process focuses on the operation of mechanical equipment, lighting, and related controls, and is intended to optimize how equipment operates as a system. RCx projects produce typical savings of 12-15% of total building energy costs, with a simple payback from energy savings alone averaging less than 2 years[2]. In California alone, a recent study estimated $9.5 million in potential energy savings from retrocommissioning only 2% of the buildings greater than 25,000 square feet. In addition to significant energy savings, retrocommissioning reduces maintenance costs, provides complete and accurate building documentation, provides appropriate training to operating staff, aids in long term planning for retrofits, and increases the asset value of a building.

[1] PECI. 1998. National Strategy for Building Commissioning. U.S. Department of Energy.

[2] PECI. 2000. California Commissioning Market Characterization Study. Report prepared for Pacific Gas and Electric Company.

Market Barriers

With significant savings achievable, it may be surprising that market penetration is so low for retrocommissioning services. In general, there is a lack of demand for retrocommissioning due to three main market barriers:

1. There is a lack of awareness of retrocommissioning's benefits.
2. The first cost of retrocommissioning is too high to be funded through tight building operations budgets.
3. Inconsistent approaches to retrocommissioning do not give a sense of the product that owners receive.

In addition, previous retrocommissioning programs have revealed three critical difficulties that have hindered success:

- *Securing buy-in from building owners to participate in retrocommissioning programs has been difficult.* Government and institutional owners have had some level of participation, but the private commercial buildings market is untapped.
- *Ensuring persistence of savings in a cost-effective manner is challenging.* Requirements for cumbersome levels of documentation and methods for savings analysis do not use funds effectively.
- *Supporting large amounts of commissioning is unmanageable when utilizing only a few commissioning providers.* Without a clearly defined process for participation, many commissioning providers are not effectively incorporated into a retrocommissioning program to complete commissioning jobs and achieve energy savings.

Keys to Successful Program Implementation

These market barriers and programmatic difficulties are common limitations for incentive programs, and require innovative solutions. The program presented in this proposal is designed to overcome these issues by incorporating the following elements:

- **Reaching the private commercial buildings market through innovative marketing efforts and leveraging the utility-customer interface.** Due to their highly risk-adverse structure, private commercial building owners are traditionally a difficult sector to reach for energy efficiency efforts. Therefore, the program incentives will be structured in a way to encourage participation rather than box the owner into agreements that do not fit with their accepted level of risk. In other current programs, PECI markets to similarly tough audiences in innovative ways, including independent grocers and small commercial HVAC service providers. Including a marketing budget for utilities will leverage their strong presence with owners to market the Statewide RCx Program. Through partnering with local governments such as the City of San Francisco, the Program will more easily sign up customers that are eager for retrocommissioning services.
- **Ensuring the persistence of savings through carefully targeted requirements for building documentation, training, and energy tracking.** A challenge in the commissioning industry is how to prove that the benefits last. Verifying persistence of savings is a key goal of this program. The systems developed to produce these long-

lasting results are a result of our extensive experience in monitoring building performance, working with building operators to understand their needs, and delivering commissioning training to many audiences. Through these experiences, documentation and monitoring requirements will be streamlined to ensure the program delivers persistence of savings in a cost-effective manner.

- **Building the California commissioning infrastructure by providing a consistent retrocommissioning platform and training commissioning providers on the program.** The Statewide RCx Program will be run using the traditional trade ally design – a framework that has worked well for the California utilities' past programs. This framework will ensure longevity and repeatability of the program under any scenario of program administration. The retrocommissioning protocol and training will ensure a high quality of commissioning services that routinely uncovers significant energy savings opportunities with attractive paybacks to owners. The Statewide RCx Program presents a unique opportunity to grow the commissioning industry in California by providing opportunities for more commissioning providers to achieve a broad impact across the State.

C. Program Objectives

The program objectives of the Statewide RCx Program during 2004-2005 are as follows:

- **39.9 million kWh** in annual energy savings and **5 MW** of peak demand reduction in a area of building energy efficiency that is untapped by the market.
  - PG&E: 19,032,300 kWh; 2,385 kW
  - SCE: 14,643,300 kWh; 1,835 kW
  - SDG&E: 6,224,400 kWh; 780 kW
- Retrocommission **20 million square feet** of building area.
  - PG&E: 9,540,000 square feet
  - SCE: 7,340,000 square feet
  - SDG&E: 3,120,000 square feet
- Improve the ability of building operations staff to identify wasteful energy use.
- Ensure savings created in this program persists over the expected lifetime.
- Ensure quality control to the owner for a well-delivered retrocommissioning process.
- Train commissioning providers on providing a high caliber, cost-effective retrocommissioning service.

Section II: Program Process

A. Program Implementation

This section describes the overall approach that will be used to implement the proposed Statewide RCx Program. The program will tap into the existing commissioning industry in California for retrocommissioning services and will assure long-lasting benefits by completing the following tasks:

- Develop a retrocommissioning program protocol
- Pre-qualify commissioning providers and conduct program orientation sessions
- Provide ongoing tracking and quality control
- Train retrocommissioning providers
- Ensure persistence through performance tracking

These retrocommissioning program tasks are discussed below.

Task 1. Retrocommissioning Protocols

The program team will finalize development of several protocols for delivering retrocommissioning services. These protocols are designed to carefully select and implement the best opportunities for long-term savings, confirm owner commitments to action, and ensure persistence. Participating commissioning providers will use this protocol to comply with program requirements and receive incentive payment. While leaving flexibility for individual commissioning provider styles, the protocol is a framework that will provide the requirements for the Program, clear expectations for commissioning providers and customers, and quality control. Commissioning providers that qualify will complete a thorough retrocommissioning process using the protocol elements listed below:

1. Candidate Screening Protocol
2. Scoping Study Protocol
3. Investigation Protocol
4. Implementation Protocol
5. Persistence of Savings Protocol

Candidate Screening Protocol

Candidate screening determines whether a building is a good candidate for a retrocommissioning scoping study. The program will provide a screening tool that helps prioritize retrocommissioning opportunities. Buildings may be less desirable candidates for retrocommissioning due to their small size, their imminent need for a major retrofit, or a lack of automated building control system. Other screening criteria that will be incorporated into the screening tool are energy use intensity and HVAC equipment configuration.

Scoping Study Protocol

In the scoping study, the commissioning provider assesses the potential for low-cost energy conservation, O&M, and demand reduction opportunities. The program will cover the cost of the scoping study, with the submission of a scoping study report that follows the protocol. The scoping study provides a concrete basis for the owner to make the commitment of resources for the next step. It also includes an actionable plan for executing the retrocommissioning process on each specific building.

In order to proceed with the retrocommissioning process, the facility must repair major maintenance items to achieve basic functionality of the system. These items may include replacing belts, repairing broken damper linkages, and calibrating key control sensors. Without these maintenance items repaired, the commissioning provider will not able to evaluate the operation of the system.

Retrocommissioning can help extend life of the equipment, however, for equipment that is scheduled to be replaced soon, the facility will be directed to the Standard Performance Contracting utility programs to complete the retrofits.

Program Requirement 1: Scoping Study

Investigation Protocol

The retrocommissioning investigation protocol will include details about how to document findings and calculate energy savings. During the investigation phase, the commissioning provider will complete a findings list and simple payback analysis. This analysis will be submitted to the program for calculation of the incentive that would be received if the findings were implemented.

The findings from the investigation will focus on low-cost improvements with short paybacks, but major capital improvement opportunities may also be identified. Major capital improvement opportunities will be documented in a list of potential retrofits and supplied to the owner for planning purposes. The commissioning provider will direct the owner to the utilities' Standard Performance Contracting program to complete these retrofits.

The commissioning provider will present the retrocommissioning findings, savings, and incentives to the decision-maker at the facility, and assist in selection of improvements for implementation. The final package of improvements and incentives will be reviewed by the Program.

Program Requirement 2: Findings list and simple payback analysis submitted for custom incentive calculation. If applicable, a list of potential retrofits.

Implementation Protocol

After repairs and improvements are chosen, the commissioning provider will be a resource to ensure proper implementation. The commissioning provider's continued involvement will help maintain momentum to realize energy saving opportunities. For example, the commissioning provider will help explain a control strategy improvement to the controls contractor that is implementing a change to avoid miscommunication.

Implementation activities for the commissioning provider include:

- Recommendations to the facility staff on how to implement improvements.
- Help facility staff implement improvements.
- Document implementation in the master findings list.

Program Requirement 3: Confirm implemented measures.

Persistence of Savings Protocol

The commissioning provider will work with the facility staff to ensure that the savings from retrocommissioning persist over time. The Program will finalize guidelines for the following steps to maximize persistence of measures:

- **Systems Manual.** The commissioning provider will update the commissioned systems documentation, or provide accurate documentation where none exists through the creation of a targeted Systems Manual. This manual will document the building set points, control sequences, and common system problems. The Systems Manual will focus on those systems necessary to ensure the persistent performance of the program retrocommissioning improvements; other systems documentation will be the sole responsibility of the owner. The Systems Manual is critical to persistence because it is a resource to operators for the life of the building.
- **Tracking System.** With technical assistance from the Program as necessary, the commissioning provider will set up a system for tracking persistence of savings. The system will monitor key problems that were fixed through commissioning by utilizing dataloggers or the existing EMCS trending capabilities. The tracking system information will be made available directly to the facility managers and building operators. Information from this tracking system will also be available for analysis in the Program's EM&V process. This monitoring process will be focused on the information necessary to track the program's retrocommissioning improvements only, other monitoring and control system improvements will be the sole responsibility of the owner. The tracking system is described in more detail in Task 5.
- **Training.** To help ensure that the building continues to run optimally after retrocommissioning, building operators will be trained on the updated building documentation, changes to control sequences, and the tracking system.

This combination of documentation, tracking and specific project training is the key to persistent savings. We have found that these elements often lead to increasing savings over time.

Program Requirement 4: Targeted Systems Manual, tracking system, evidence of training session, and final findings list including documented improvements.

Task 2. Cx Provider Pre-qualification and Program Orientation

The program team will publish eligibility criteria for commissioning providers and will evaluate provider qualifications for eligibility. Eligibility criteria will include demonstrated experience in HVAC systems, control systems, diagnostics, monitoring, functional testing and energy savings calculations.

Qualified providers will also be required to participate in a Program Orientation. The half-day Program Orientation will cover the required retrocommissioning program protocols for the scoping studies, the retrocommissioning analyses, implementation of fixes, documentation, operator training, and tracking system. Six retrocommissioning Program Orientations will be held in each year of the program.

Task 3. Ongoing Retrocommissioning Program Operations

To ensure success of the retrocommissioning program, a quality control process will be established. PECI and AEC will provide technical assistance to the commissioning providers and modify the program procedures to ensure that owner/management firms are being well served by the commissioning providers.

Oversee Retrocommissioning Projects

PECI and AEC will track individual projects in the program through the following activities:

- As commissioning providers begin participation in the program, the participating owner/management firms will be contacted to ensure that the program has been properly explained.
- PECI and AEC staff will oversee the efforts of the commissioning providers more closely in the initial buildings retrocommissioned, with interviews of owners and site visits as required.
- Throughout the program, documentation from each step of the retrocommissioning project will be reviewed. The table below lists the documents that will be reviewed.

Retrocommissioning Phase	Quality Control Documentation
Scoping	Scoping study report
Investigation	Findings list with energy savings calculations
Implementation	Confirmation of implemented measures
Persistence of Savings	Building Systems Manual Tracking System Training Report

Overview of Program Process

Figure 1 summarizes the process for completing a retrocommissioning project, from identifying candidates to incentive payment. The Program will help utilities and commissioning providers screen the facilities to determine the best candidates for retrocommissioning. The Program will then assist the owner in selecting a commissioning

provider from the pre-qualified provider list if they are not already working with one. The commissioning provider will contract directly with the owner, and all incentive payments will be made to the owner with the exception of the scoping study payment.

After the scoping study, a building with non-functioning equipment will be directed to complete repairs that affect the ability to perform retrocommissioning services. Next, the commissioning provider completes the retrocommissioning investigation, helps the facility staff select items for implementation, aids implementation when necessary, and sets up the tracking system.

For quality control, the Program will perform a site visit of the first project completed by each participating commissioning provider. The Program will visit 15% of ongoing completed projects to verify that the tracking system is in place and the measures were implemented properly.

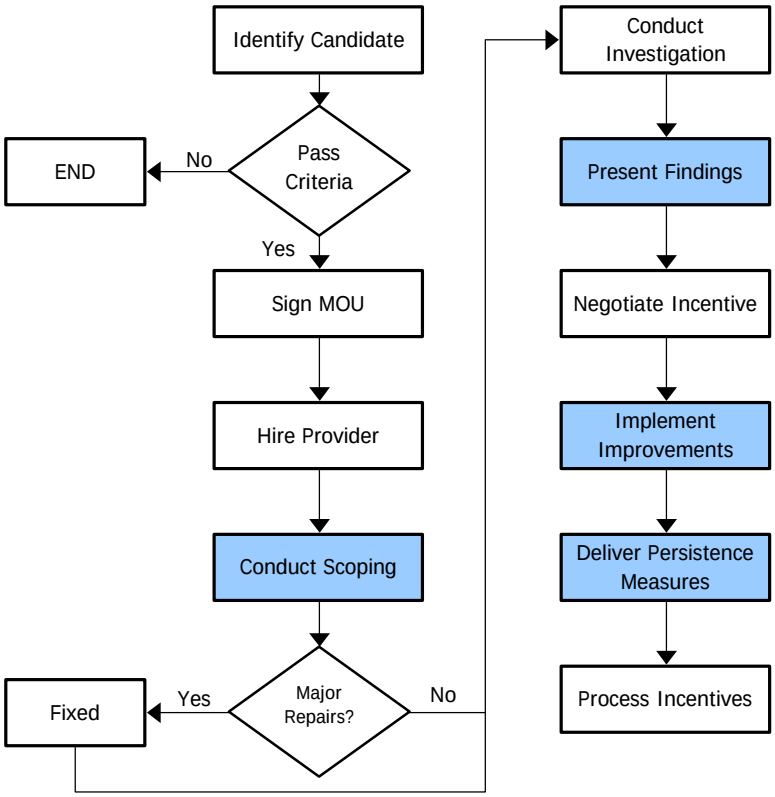


Figure 1: Overview of Project Process. Shading indicates areas with Program requirements for commissioning providers

Program Modifications

Throughout the process, the program administrators will be available to answer questions about program requirements. PECI will fine-tune the program design to streamline the participation process for commissioning providers and owner/management firms.

Task 4. Retrocommissioning Training

To build the infrastructure for quality retrocommissioning process, a multi-day retrocommissioning training course will be made available to potential and existing commissioning providers. The training will be designed to provide hands-on experience through participation in a example retrocommissioning project led by the instructor at a nearby building. Participants will benefit from working with an experienced commissioning provider in a well-developed framework for providing retrocommissioning services. Training topics include:

1. Scoping study – tools and techniques
2. The system approach
3. Efficient methods for uncovering problems
4. Working with the building staff
5. Calculating the savings
6. Implementing the findings
7. Providing a targeted Systems Manual
8. Marketing retrocommissioning services

Participants will leave the training with an understanding of the retrocommissioning process and how to apply that process in a real building.

Task 5. Ensuring Persistence Through Performance Tracking

The project team has conducted studies of retrocommissioning persistence and found a greater persistence of commissioning benefits when building operators were well-trained and tracked building performance[3]. Our experience has shown that well-informed owners and operators not only ensure that retrocommissioning savings persist, but they work to create additional savings. Savings need to be monitored and actions need to be taken periodically to fine tune building performance.

A component of the Statewide RCx Program is our use of data analysis technologies to ensure persistence of savings. The commissioning providers will propose a tracking system to monitor the improvements implemented in each building. The program will assist in the development of these plans where needed. These systems will track critical points for verification of the performance and persistence of improvements, and will provide that information to the program and the building operators. This approach ensures that the CPUC can place a high level of confidence in the realization of the savings from this program.

[3] H. Friedman, A. Potter, T. Haasl, D. Claridge, S. Cho, "Persistence of Benefits from New Building Commissioning", Proceedings of 11th National Conference on Building Commissioning, May 20-22, 2003.

The performance tracking systems in this program will consist of three elements:

1. Data collection and local data storage.
2. Data transfer to the Program.
3. Data analysis, display, and feedback.

Data Collection and Local Data Storage – Commissioning providers will develop a tracking plan that will be approved by the Program. If providers lack the expertise to set up an approved tracking system, the Program will help perform this service. The tracking system implemented at each building will be customized to take maximum advantage of the capabilities already installed at each site. To keep the costs down, the data requirements (sensors and frequency of data collection) recommended for each building will be focused on the measurements needed to ensure persistence of savings and those needed for measurement and verification activities.

Data Transfer to Program– The data stored at each building will be transferred to the program for analysis, display, and feedback. The method used for data transfer will depend on the capabilities that exist at each building. Where possible, the data transfer method will be via the Internet using the local area network (LAN) installed at each building. The second possible mode of data transfer is via wireless modem technology. This technology is reliable, but is more expensive to install than the LAN-based system and requires a monthly fee.

Data Analysis, Display, and Feedback – Data will be analyzed by the Program through 2005 to make sure systems continue to operate properly after the retrocommissioning activities. The Program team will run diagnostic routines, will check for limits, and will run correlation analyses with the data. The development of server-based diagnostic capabilities is currently near completion through a California Energy Commission PIER program, and will be utilized by this program as it becomes available. Building owners, operators, or maintenance personnel will have the ability to access this server over the Internet. The site will also allow them to view time-series plots of the data, view performance plots, or download the data. The site will be able to send e-mail messages to operations and maintenance personnel alerting them when performance is not as expected.

B. Marketing Plan

The marketing plan is designed to recruit and leverage existing customer contacts and networks within the utilities and participating local governments. The target audience is best approached through existing relationships and the utilities and local governments are the best source of existing relationships that can be tapped for recruitment. Commissioning providers and the program itself will also recruit owners.

The marketing messages will be designed to inform owners about retrocommissioning and spur them to take advantage of the energy saving opportunities. The marketing plan provides materials that have consistent messaging from credible sources and can be used by the providers, utilities, local government partners, and program staff to build awareness and enroll participants.

Recruitment

Currently, market demand for retrocommissioning services is still low, except in certain markets where long-term ownership interests are high, such as government buildings and schools. Until the industry expands and awareness is heightened, program participants must be actively recruited. Recruitment will occur through several market players using a variety of methods that are summarized below.

Utility Representatives

This program will negotiate with the utilities to assist with program marketing along with their existing complementary programs. The utility representatives provide a direct link to key accounts. They are viewed as a credible source of information and an invaluable resource. The program has earmarked funds to compensate for the utility's marketing services and will make every effort to enlist utility support. Once enlisted, a program kick-off meeting will be held to gather input from the participating utilities. The marketing strategy will leverage the utilities customer knowledge and access to energy usage data to identify likely targets. Utility representatives would then present the program opportunity through the normal course of interaction with customers. If the utilities are unable to participate actively, these marketing funds will be used for additional program marketing efforts.

Local Governments

The energy or environmental offices of major metro areas provide another avenue to potential participants. The city offices have access to planning departments and other information systems to help target participants. For this proposal, we have teamed with the Department of the Environment of the City and County of San Francisco (CCSF) in PG&E's service territory (see Attachment A for support letter). CCSF is participating in the Peak Energy Program (PEP) funded by the CPUC through 2004 and will co-market to that audience. When that program ends in 2005, the CCSF efforts will shift to all candidates, rather than only those in the PEP program. Upon contract award, we will seek to work with other cities in a similar manner.

Commissioning Providers

Commissioning providers have an existing network of contacts and will be valuable marketers of the program. The program will develop marketing materials for commissioning providers to use in bringing customers to the program.

Program Administrators

While this program is designed to recruit and leverage existing customer contacts and networks, it will provide additional recruitment through outreach efforts, including attending BOMA and IFMA meetings, using Chamber of Commerce materials, hosting owners breakfasts, and tapping into other professional organizations. The approach will raise general awareness and provide information about finding qualified commissioning providers.

Target Audience & Key Messages

The marketing campaign addresses four target audiences: building owners, facility managers, O&M staff, and tenants. Each audience is directly impacted by building operation and can influence the decision to perform retrocommissioning.

Building Owners

The building owner audience includes building owners, owner occupants, owner representatives, property manager companies, and other financial decision-makers. They are the group that has the most at stake and ultimately makes the decision whether to participate.

Key messages for owners include:

- Retrocommissioning will increase the NOI (net operating income), thus supporting a higher appraisal value.
- Retrocommissioning will improve tenant comfort and retention. The cost of losing one tenant could easily outweigh the cost of RCx.

Facility Managers

Facility managers are responsible for the operation of the entire facility and typically work for the owner or property manager.

Key messages include:

- Improved facility operation
- Reduction in occupant complaints

Operation & Maintenance Staff

The O&M staff are responsible for keeping the facility operational and well-maintained. The staff has the best working knowledge of the system functions and common problems. This audience has a direct impact on the persistence of any improvements.

Key messages include:

- Increased level of expertise by participating in the process (training)
- Increased equipment reliability
- Improved system operation, problems fixed

Tenants

The building tenants in large office buildings are typically large corporations. Depending on the lease arrangement, they may not pay the utility bills, but are likely to be sensitive to impacts that can effect daily operations. Key messages include:

- Improved occupant comfort
- Increased occupant productivity

Materials

Marketing materials will be designed with a consistent look and message. Materials will include a brochure, fact sheets, and presentations that can be customized. The materials will explain the program approach, the energy savings potential, and available financial assistance, and include brief case study information. The program, utilities, local governments and providers will use the materials to aid in recruitment.

Website

The program website will be an integral part of promoting the program. It will contain all the marketing materials in an easy to download format. In addition, it will contain the program requirements, the retrocommissioning protocols and retrocommissioning resources for providers and owners.

C. Customer Enrollment

Following the customer recruitment process (described in the previous section) and eligibility approval, participating customers will be required to sign a Memorandum of Understanding (MOU) to confirm their enrollment in the Program. The MOU will be a binding agreement of participation and will be guided by the requirements detailed in the program protocol. In addition, the MOU will clearly articulate the terms under which the Program will dispense incentive payments for retrocommissioning services. Upon signing the MOU, the customer will engage and contract retrocommissioning services directly with the commissioning providers.

D. Materials

Through the retrocommissioning and/or testing of over 500 buildings, PECI and AEC have found many common operational problems that have gone undetected and uncorrected by the operations and maintenance staff. The Statewide RCx Program will target these common problems found in HVAC and lighting systems, and will include measures to address the following systems:

Chillers – Chillers are often the single biggest equipment loads in commercial and institutional buildings and almost always set the peak summer demands. Operators tend to be more concerned with maintaining comfort than they are about the energy efficient operation of the equipment. Consequently, three operating scenarios commonly occur that result in excess energy use. These are usually easy to remedy by reprogramming the building automation system. The three common scenarios are described below.

- **Chilled water setpoint too low**. Operators often lower the chilled water setpoint during periods with peak cooling loads. However, they forget to reset it and it remains at the low value continuously or until they receive complaints of discomfort. Raising the setpoint by a few degrees during periods of smaller loads can save substantial amounts of energy. Often automatic chilled water reset controls have been overridden or were never employed during the initial start-up of the chiller system.
- **Improper staging.** Most electric chillers are more efficient operating at higher loads. Many buildings will have more than one chiller. Quite often two chillers will operate at low loads, when one has sufficient capacity to meet the load. For more energy efficient operation, a single smaller chiller should be used to meet lower loads, and multiple chillers used to meet the higher ones.
- **Chillers energized when unnecessary.** Chillers are often operated when outdoor air can meet cooling loads with airside economizers. This results in the chiller being operated at low loads when they are not needed. Carefully determining the "balance point" of the building and then setting an appropriate ambient lockout can reduce the number of hours a chiller is operated.

Collecting and analyzing chiller performance data is the only way to determine if their dynamic performance is optimal. Potential chiller problems that are investigated using time series data include: proper staging, proper temperature resets, meeting load or drifting, maintaining proper temperature differentials, short cycling, and calculated efficiency (kW per ton).

Cooling Towers – Cooling towers are a key component of most large cooling systems and their performance and operation can have a large impact on the efficiency of the chillers and the total energy use and peak demands of the entire cooling system. The following three common operational characteristics of cooling towers can cause excess energy consumption:

- **High condenser water temperatures.** Similar to the condition for chilled water temperature discussed above for chillers, the condenser water temperature is often set too high. Electric chillers run more efficiently at low condenser temperatures.
- **Excessive cycling of fans**. This condition is most common on large towers with single, constant speed fans. Excessive cycling is common at low loads and causes wear on motors and drive systems (belts, pulleys, etc). This condition can be reduced by slightly increasing the control deadband of the condenser water setpoint or installing two-speed motors or variable speed drives.
- **Poor maintenance.** This reduces heat transfer efficiencies and requires excess fan energy to reject heat from a tower. It is often a result of poor water treatment.

Time series performance data collected on cooling towers is used to investigate: approach to wet bulb temperatures, condenser water temperature differential, condenser water reset, and fan cycling and staging. Static tests are not sufficient to investigate these parameters over a range of operating conditions.

Economizers – Economizers are designed to reduce the need for mechanical cooling when outside air conditions can provide "free cooling." Only a small percentage of the economizers we have studied actually work properly. The following three common operational faults in economizers can cause excess energy consumption and increased peak demand:

- Outside air dampers are locked in the minimum air setting and "free cooling" is never realized. Mechanical cooling is necessary at times when free cooling should be available. This increases the cooling requirements in morning and evening hours, as well as during the cooler swing months.
- Outside air dampers are locked in the maximum air setting and free cooling is realized, but the peak loads are increased. These excess loads are particularly prevalent during the hottest hours on summer months.

Restoring economizers to proper operation reduces both energy consumption and peak summer demand. Only time series data will reveal these problems over a range of operating conditions. It will also clearly show the interaction between the operation of system components, such as the economizer and chiller or compressor.

Simultaneous Heating and Cooling – Oftentimes, heating and cooling are supplied to spaces at the same time. This can happen if a space is cooled and heated using independent controls. The heating and cooling systems can run simultaneously without causing perceptible comfort problems, so these conditions are rarely reported to maintenance personnel. Eliminating simultaneous heating and cooling is often a matter of the following inexpensive changes:

- Coordinating setpoints
- Locking out the heating during summer months
- Reducing overventilation
- Changes to control logic

Controls – Control systems are often the most problematic system in a building. Improving and changing the controls to a building can result in significant energy savings. The following strategies are commonly implemented during retro-commissioning:

- Scheduling for HVAC and lighting systems according to demand
- Correctly programming reset schedules for supply air and hydronic systems
- Correcting operation when VFD turndown is limited
- Improving the ability to meet setpoints without oscillations or cycling of equipment
- Addressing interactions between systems to avoid cascading instability

Control problems can be found through observation and analysis of time series data. Control problems are often easy to find because operators are aware the problems and have found creative solutions to handle the symptom. Retrocommissioning addresses the root cause.

E. Payment of Incentives

The Statewide RCx program includes incentives for the scoping, investigation and implementation of retrocommissioning services. All incentives will be paid to the customer with the exception of the scoping study which is a flat fee paid directly to the provider.

Component	Incentive Description
Scoping	$2,500 flat fee
Investigation	$0.10 per square foot
Implementation	Custom incentives will be determined using the following guidelines: ■ Based on energy savings with an average incentive of $0.025/kWh. ■ Payback threshold less than 6 years. ■ Financial caps ■ Some cost sharing by the owner.
Tracking for persistence	$0.09 per square foot

Documentation from the scoping study, investigation process, improvements implemented and tracking system will be required as a condition of payment. Each deliverable will be reviewed and analyzed for completeness.

Upon approval, the program will generate a check request for the provider or owner. The check request and accompanying documentation are approved by the Program Manager and sent to Accounting.

Accounting cuts the check and returns it to the program staff. The program makes copies of all rebate checks and keeps them in the project file. The check is sent to the owner, accompanied by a cover letter thanking the customer for participating in the program. All

documentation is retained at PECI for a period of seven years, and made available upon request to program administrators and auditors.

F. Staff and Subcontractor Responsibilities

PECI, the primary implementer, and AEC, the primary subcontractor, will largely share responsibilities for program implementation. Table 1 below indicates how the implementation tasks will be allocated. PECI will take the lead on developing the program structure, qualify commissioning providers, and trainings, while AEC will manage the tracking protocols for persistence of savings. Overall however, program development and implementation will be a collaborative effort, drawing from the strengths and expertise of both organizations.

Table 1: Program Tasks

Task	AEC	PECI
Refine program concept	Support	Lead
Develop the retrocommissioning protocols	Joint Task	
Develop eligibility criteria for commissioning providers	Support	Lead
Pre-qualify commissioning providers	Support	Lead
Present six program orientations per year	Support	Lead
Write RFPs for each retrocommissioning project	Support	Lead
Select commissioning providers	Support	Lead
Develop and present a multiple-day retrocommissioning training	Support	Lead
Review the required retrocommissioning deliverables for quality assurance purposes	Joint Task	
Provide technical assistance to commissioning providers and facility staff	Lead	Support
Develop tracking protocols to ensure persistence of savings	Lead	Support
Perform tracking protocol when Cx provider is not able to provide the service	Lead	Support
Review retrocommissioning projects to ensure persistence of savings	Lead	Support
Process incentive payments		Lead

Figure 2 illustrates the organizational structure of the program and the relationships among the stakeholders. The primary responsibilities of each stakeholder group are shown on the left-hand side.

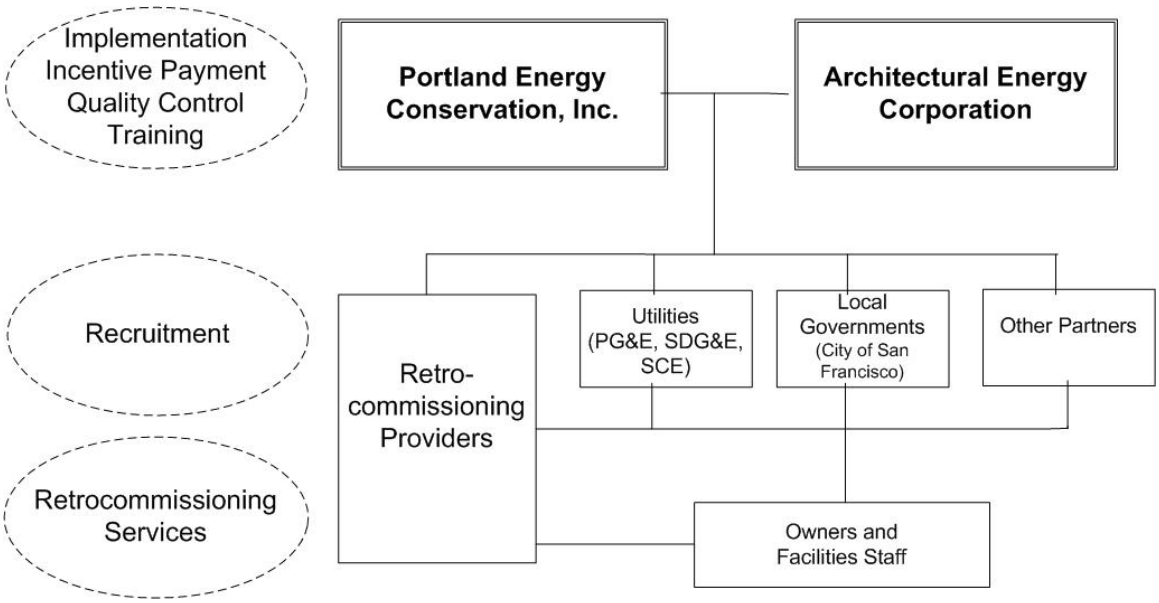


Figure 2: Organizational Chart

Table 2: Staff Responsibilities for PG&E Program Proposal

Position Title	Staff Name	Primary Responsibilities	% of Time Devoted to Program
Associate Director	Tudi Hassl	Technical guidance	6%
Sr. Program Manager	Amanda Potter	Guide overall program strategy and implementation	36%
Project Engineer	Larry Luskay	Pre-qualify and train commissioning providers, oversee RCx deliverables	24%
Project Coordinator	Emily Moore	Coordinate with building owners and commissioning providers	48%
Project Coordinator	Steve Cofer	Process incentive payments	12%

Table 3: Staff Responsibilities for SDG&E Program Proposal

Position Title	Staff Name	Primary Responsibilities	% of Time Devoted to Program
Associate Director	Tudi Hassl	Technical guidance	2%
Sr. Program Manager	Amanda Potter	Guide overall program strategy and implementation	12%
Project Engineer	Larry Luskay	Pre-qualify and train commissioning providers, oversee RCx deliverables	8%
Project Coordinator	Emily Moore	Coordinate with building owners and commissioning providers	16%
Project Coordinator	Steve Cofer	Process incentive payments	4%

Table 4: Staff Responsibilities for SCE Program Proposal

Position Title	Staff Name	Primary Responsibilities	% of Time Devoted to Program
Associate Director	Tudi Hassl	Technical guidance	5%
Sr. Program Manager	Amanda Potter	Guide overall program strategy and implementation	28%
Project Engineer	Larry Luskay	Pre-qualify and train commissioning providers, oversee RCx deliverables	18%
Project Coordinator	Emily Moore	Coordinate with building owners and commissioning providers	37%
Project Coordinator	Steve Cofer	Process incentive payments	9%

G. Work Plan and Timeline for Program Implementation

The work plan and timeline in Figure 3 below projects the first two years of program development and implementation. It is anticipated that, by the second quarter of the program's first year, retrocommissioning program protocols will be developed and participant recruitment efforts and commissioning provider trainings will be underway. The work plan also accounts for quarterly reports that will be prepared for the CPUC and assess the ongoing progress of the program.

	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
I. Start-up								
Develop Protocols	■							
Develop contractor qualificiation criteria	■							
Conduct program orientation		■	■	■	■	■		
II. Marketing								
Design & produce marketing materials	■							
Recruit local government partners		■	■					
Participant recruitment		■	■	■	■	■	■	■
III. Operations								
Ongoing program operations			■	■	■	■	■	■
Program Modifications					■			
IV. Training								
Develop Training Curriculum	■							
Conduct training courses		■		■				
V. Reporting								
Prepare quarterly reports	■	■	■	■	■	■	■	■

Figure 3: Project Milestones and Timeline

Section III: Customer Description

A. Customer Description

Desirable characteristics we look for in buildings include:

- Greater than 100,000 square feet
- Utilizes direct digital controls (DDC)
- High electricity consumption
- Mechanical equipment in relatively good condition

The primary market actors targeted will be building owners and key financial decision-makers. To date, most retrocommissioning has occurred in government-owned and institutional buildings. Therefore, the hard-to-reach market sector for retrocommissioning includes commercial office buildings. As discussed in a previous section, private commercial building owners are traditionally difficult to recruit for energy efficiency efforts because of their risk-adverse business structures. The Statewide RCx Program and the marketing plan are designed to directly address these market barriers and spur the market for retrocommissioning in the private sector. The Program will aim to have 30% of program participants be leased buildings, which are considered a hard-to-reach market for retrocommissioning.

B. Customer Eligibility

The Program will be available to all commercial customers who pay electric public goods charges as provided under the California Code and regulated by the CPUC within the service territories of PG&E, SCE, and SDG&E.

C. Customer Complaint Resolution

Any question and complaint raised to the program manager, utility, or service provider will be directed to the Program Manager. The Program Manager will gather information and investigate to ensure an immediate resolution. The utility will be informed of all conflicts that arise.

D. Geographic Area

The program will be available to customers within the service territories of PG&E, SCE, and SDG&E. The majority of buildings will be found in the urban areas of San Diego, Los Angeles, San Francisco, Oakland and San Jose.

Section IV: Measure and Activity Descriptions

This section explains the sources and rationale behind the various measures and activities behind the implementation of the Program.

A. Energy Savings Assumptions

Electric energy savings and peak demand savings were estimated using data gathered in the Commercial Building Energy Initiative (CBEI) program, a 2001 Third Party Program funded by Southern California Edison and the California Public Utility Commission[4]. We anticipate that this Statewide RCx Program will have greater energy and demand savings than the CBEI program due to our tracking methods that will ensure persistence of savings.

Coincident Peak Demand Reduction

Coincident peak demand reduction is estimated at 25 W/square foot based on results from the CBEI program.

Electric Energy Savings

Electric energy savings are based on the following assumptions:

- 13.3% savings (CBEI average)
- 15 kWh/square foot, building energy use intensity (CBEI average)
- 20 million square feet will be retrocommissioned statewide.
    - PG&E: 9,540,000 square feet
    - SCE: 7,340,000 square feet
    - SDG&E: 3,120,000 square feet

B. Deviations in Standard Cost-effectiveness Values

Net-to-Gross Ratio

A net-to-gross ratio of 1 was used to be consistent with the currently funded CPUC retrocommissioning program.

Estimated Useful Life

An estimated useful life of 8 years was used to be consistent with the currently funded CPUC retrocommissioning program.

[4] California Building Energy Initiative, Pilot Project Final Report, SCE Purchase Order #F104907, June 2002.

Incremental Measure Cost

Incremental measure cost is estimated at $0.27/square foot using the results from the CBEI program. In the CBEI Program, $559,770 was spent program-wide implementing retrocommissioning measures in 2,055,908 square feet.

C. Rebate Amounts

Incentives will be paid for the scoping study, investigation, implementation and tracking of RCx. Table 5 summarizes the program incentives and rationale for each incentive.

Table 5: Program Incentives

Component	Incentive Description	Rationale
Scoping Study	$2,500 flat fee	Incentives will cover the cost of the scoping study up to $2500. The intent of the scoping study is to determine if the building is a good candidate. Based on our experience, owners need this study covered in full since they are not familiar with the benefits of retrocommissioning.
Investigation	$0.10 per ft^2	Incentives will cover most of the cost of the investigation. During the investigation, the provider will identify energy savings. Based on our experience, owners need most of the cost covered since they are not familiar with the benefits of retrocommissioning.
Implementation	Custom incentives will be determine using the following guidelines: ■ Cost sharing by the owner. ■ Determined based on energy savings with an average incentive of $0.025/kWh energy savings. ■ Payback threshold less than 6 years. ■ Financial caps	Incentives for implementation will cover a portion of the implementation costs. Based on our experience, owners are far more ready to implement energy savings improvements if they are given some financial incentive.
Tracking	$0.09 per ft^2	Incentives for tracking will cover most of the initial tracking costs. Our experience has shown that owners need an incentive to start an energy tracking system but once the system is operational and the benefits demonstrated, owners are very willing to pay ongoing tracking costs.

D. Activities Descriptions

The program activities that support the energy savings achieved, but do not directly achieve energy savings by themselves are as follows:

- Scoping Study
- Retrocommissioning investigation, including a findings list and simple payback analysis
- Commissioning provider training on retrocommissioning

Each of these activities is described in detail in Section II.A. Program Implementation.

Section V: Goals

The Statewide RCx Program goals are shown below in Table 6. The program will result in total annual energy savings of 39.9 million annual electric savings and 5 MW peak demand reduction. Table 6 provides the proposed energy savings and demand reduction targets in each utility service territory.

Table 6: Program Goals

	Energy Savings (kWh)	Peak Demand Reduction (kW)
PG&E	19,032,300	2,385
SCE	14,643,300	1,835
SDG&E	6,224,400	780
Total	39,900,000	5,000

Section VI: Program Evaluation, Measurement, and Verification (EM&V)

Members of the Program team have conducted many measurement and verification (M&V) process evaluations for the utilities in California and for other utility companies around the country. We are familiar with the methods and protocols for implementing these activities. This evaluation, measurement and verification (EM&V) plan for the Statewide RCx Program meets the EM&V objectives of the Commission outlined in the Energy Efficiency Policy Manual and adheres to the guidelines in the International Performance Measurement and Verification Protocol (IPMVP).

Approach for Evaluating Energy Savings

The EM&V for the program is based on established methods for evaluating commercial retrofit and commissioning program success. The energy efficiency improvements that will be made to each building participating in the program will be determined during the data analysis and engineering phases of each project. This differs from other types of programs, such as lighting or motor retrofits, where the replacement energy efficient technologies are known at the outset, and the measurement and verification (M&V) methodology does not change from project to project. The general approach to M&V for the program is to use data loggers that are part of the diagnostic process to take measurements at each site before improvements are made, to use the energy information system at each site to take measurements after improvements are made, then apply Option B or Option D from the IPMVP to calculate energy and demand savings. Details of this tailored approach are explained in the section below. The Program team will report energy and demand savings to the sponsoring utility (or utilities) and to the Commission on a periodic basis.

The key objectives of the M&V activities are to:

- Establish baselines for each participant site.
- Calculate demand and energy savings for each participant site.
- Develop on-going gross whole-building energy and demand impact estimates.
- Develop on-going estimates of both free-ridership and spillover at the measure and end-use levels.

Approach for Evaluating Program Process

The EM&V plan also includes a process evaluation plan to assess program awareness, effectiveness of program policies and procedures, customer satisfaction with the program, benefits to participants, barriers to program participation, and barriers to implementing energy efficiency recommendations. Process evaluation will be conducted toward the end of the first year of the program so that improvements can be made during the second year.

Process evaluation is an important element of the program because it:

- Improves and focuses the marketing activities.
- Improves the program delivery process, which improves the cost-effectiveness.
- Determines the continuing need for the program.

Data collected during the Process Evaluation will be used to improve program design and market assessment. First, the evaluation contractor will evaluate the project teams internal processes. These have to do with the way the program tracking system is set up, the way communications between the program management team and the independent implementers are set up, and the way the data from the independent contractors comes back to the management team. The independent EM&V contractor will want to audit these to be comfortable with the quality of the performance data.

Second, surveys will be conducted involving participants and non-participants. The non-participant category will include two groups: 1) customers who have not been exposed to the program, and 2) ones who were approached, given and opportunity to participate, and decided not to participate. The surveys will gauge program awareness, perceived benefits to participating, barriers to participating, and the effectiveness of training. From the second group of non-participants we want to learn what inducements would be necessary for them to participate.

The key objectives of the process evaluation study are to:

- Investigate the accuracy of performance data.
- Provide an on-going process evaluation of the program to improve delivery efficiency.
- Determine the success of the program at persisting energy savings.
- Determine awareness of the program by potential participants, including building owners, managers, and operators.
- Determine barriers to participation in the program.
- Assess overall participant satisfaction with the program.
- Identify structural changes to streamline program design and procedures.

The results from this study will be used to refine program design and to assess whether there is a continuing need for the program.

Potential EM&V Contractors

To conduct the evaluation in the manner described above, the evaluation contractor needs to have experience with large building HVAC systems and controls, instrumentation and data analysis, building energy simulation, and survey research. We feel comfortable that any of the firms listed below can conduct a competent and objective evaluation of the program:

1 **RLW Analytics.** RLW Analytics is a leader in the field of efficiency program evaluation. RLW staff includes HVAC engineers, economists and statisticians capable of conducting the engineering analysis required for the impact evaluations and the survey research necessary to conduct the process evaluations. RLW staff have conducted evaluations of

programs involving large commercial buildings, have developed data analysis tools to handle large volumes of field data, and are experienced in the use of the DOE-2 building energy simulation program. RLW is also a pioneer in the use of model-based sampling techniques that leverage engineering and statistical sampling techniques to provide cost-effective evaluations of complex programs. RLW has also conducted process evaluations of commercial programs focusing on HVAC system improvements. RLW has no known business interests that would prevent them from conducting an objective evaluation of this program.

2 **Itron.** Itron (formerly RER) also has the capability to evaluate this program. Itron was selected as the evaluation contractor for the 2002-2003 Oakland Energy Partnership program, which contains a retro-commissioning element. This experience should be particularly relevant to the evaluation of this program. Itron's staff consists of statisticians, economists, mechanical engineers, and simulation modelers. Itron has conducted several projects involving large building HVAC systems, including the statewide commercial end-use study (CEUS). They have built and maintained several tools to collect and analyze load research data. Itron has no known business interests that would prevent them from conducting an objective evaluation of this program.

3 **SBW Consulting.** SBW participated as a subcontractor to Itron for the evaluation of the 2002-2003 Oakland Energy Partnership program. This experience should be relevant to the evaluation of this program. SBW's staff includes several mechanical engineers with large building HVAC, building diagnostics, and metering experience. They have performed several evaluations of large commercial building energy efficiency programs throughout the country. SBW has no known business interests that would prevent them from conducting an objective evaluation of this program.

Section VII. Qualifications

Primary Implementer: Portland Energy Conservation, Inc.

PECI Experience

Portland Energy Conservation Incorporated (PECI) is a private non-profit corporation specializing in innovative approaches to energy and resource efficiency. Since 1980, we have offered our clients a unique combination of expert research, program design and implementation, and on-the-ground client services. With extensive experience in engineering, education, marketing, and research, our staff holds a diversity of skills and delivers a wide range of energy services and products.

For the past 12 years, PECI has catalyzed much of the discussion, research, and development around quality assurance strategies for buildings in the United States, and has played an integral role in building the infrastructure for the growing commissioning industry. In the process, PECI has developed standardized tools, guidelines, and trainings for building owners and commissioning providers; conducted market research and influenced the design of commissioning market transformation programs; and provided building commissioning and diagnostics services to building owners and the commissioning industry.

Today, PECI is well established as a leader in commissioning industry, and has earned a reputation for delivering innovative programs that are responsive to market signals and conditions. Directly related to the scope of work for the Statewide RCx Program, PECI's work routinely includes:

- Commissioning new and existing buildings of virtually all types and sizes
- Conducting the annual National Conference on Building Commissioning (since 1993)
- Developing and producing handbooks, guidebooks, and guidelines on commissioning and O&M
- Researching and documenting "standard" and "best" practices for O&M, commissioning, and energy-responsive design
- Defining strategies for integrating energy efficiency into current construction and building-operation practices
- Designing and producing informational brochures on commissioning and O&M
- Designing and delivering workshops and training programs for utility staff, commissioning providers, and operation and maintenance staff
- Designing and conducting surveys of commissioning service providers

In addition, PECI has demonstrated competency in designing and managing large energy programs in California and other parts of the United States. Our program implementation experience includes: negotiating and managing contracts with multiple parties; creating and tracking program budgets; administering manufacturer incentives; overseeing the production

of program marketing materials; conducting education and outreach to targeted audiences; and providing technical assistance and market research.

As the primary implementer of the Statewide RCx Program, PECI will guide the program's overall design and implementation, develop the retrocommissioning protocol, and serve as the program's oversight authority.

PECI Commissioning-related Projects in California

The following projects highlight our unique knowledge, capability and expertise as it relates to the Statewide RCx Program.

National Conference on Building Commissioning (ongoing)

The fundamental vehicle for promoting the expansion of commissioning is PECI's National Conference on Building Commissioning, where market players gather to share new resources, tools, and plans for the future. PECI conceived, organized and has directed the Conference since 1993. This annual three-day event brings together more than 300 stakeholders in the building commissioning industry including building owners, service providers, manufacturers, utilities, government, and other interested organizations. Speakers from the U.S. and Canada have addressed such topics as: "Commissioning and Performance Contracting," "The Economics of Commissioning," "Commissioning and Indoor Air Quality," and "Commissioning and its Potential Impact on Liability Claims." PECI held the eleventh national conference, on May 20-22, 2003 in Palm Springs CA.

California Commissioning Collaborative (ongoing)

The California Commissioning Collaborative (CCC) is a group of utility, government, and private industry representatives working to develop cost-effective programs and a service delivery infrastructure to facilitate the commissioning of new and existing buildings in California. PECI developed an organizational structure for the CCC and proposed a funding mechanism. Currently, PECI administers the activities of the CCC, facilitating regular CCC meetings, establishing and managing funding contracts from charter members, developing scopes of work for CCC activities, issuing RFPs for specific CCC activities, and overseeing contracts established for outside parties to perform the scopes of work. CCC activities for the upcoming year include developing demonstration case studies and developing a commissioning education strategy for the state of California. http://www.cacx.org

PIER: Design and Functional Testing Guides (2002-2003)

PECI, in coordination with the Lawrence Berkeley National Laboratory, conceived, wrote and edited two comprehensive guides. The *Control System Design Guide* is a toolbox for improving control system design and specification. The *Functional Testing Guide for Air Handlers* is a detailed yet practical guide to the fundamentals of air handling system functional testing. The guide interfaces with the existing Commissioning Test Protocol Library developed by PG&E. Both guides are available on CD-ROM and on the web. http://buildings.lbl.gov/hpcbs/FTG

San Diego Gas & Electric: Allied Plaza (2002)

PECI recommissioned a 125,000 square feet office building in La Mesa, California as part of a demonstration program for SDG&E. The recommissioning process involved a coordinated effort between PECI, Architectural Energy Corporation and the building operating staff. Documents were provided for review, interviews and field investigations were conducted, and selected building systems were monitored with data loggers for a two-week period to trend system operation. The owner implemented energy conservation measures saving 208,000 kWh per year. These measures were monitored with data loggers to verify savings.

Pacific Gas & Electric Company: Commissioning Resources for Designers (2000)

PECI developed several commissioning guides and trainings for owners and designers. These materials will help customers and designers take maximum advantage of PG&E's Commissioning Support Program. Our work includes:

- *Introduction to Commissioning Handbook*. PECI developed and wrote the content for this booklet, which targets both designers and owners.
- *How-To Guide for Designers.* PECI developed and wrote the content for a guide targeted at designers. This guide emphasizes that a quality commissioning process is non-adversarial and requires a team approach.
- *PowerPoint Presentation Materials.* Based on the Commissioning Handbook and the How-To Guide, PECI developed two sets of PowerPoint presentation materials—one brief, introductory presentation and one technically-oriented full-day seminar.
- *Train-the-Trainers presentation.* PECI developed and presented this one-day seminar for utility staff on using the commissioning presentation materials
- *Guidelines for Writing a Commissioning Plan*. PECI developed a 1-2 page "cut-sheet" describing how to write a commissioning plan to be eligible for PG&E's financial incentive program.

Pacific Gas & Electric Company Training: *Top 10 Commissioning Issues* (2000)

PECI developed a one-day training seminar targeted at the 10 most common commissioning problems in new and existing buildings. Discussion of each issue covered how to identify the problem, the theory behind the problem, tools and techniques that could be used to address the problem and the potential energy and resource implications of the problem.

Pacific Gas & Electric: *Design Briefs* (2000)

PECI developed three design briefs for design professionals (architects, lighting designers, and mechanical and electrical engineers) to carry the benefits of energy efficient design through construction. PECI also delivered two workshops on the design briefs. The briefs covered:

- The proper specification of energy efficiency design details. Examples of low-cost design details that improve performance and efficiency are included.
- The effective review of schematic design documents and construction drawings. The brief discusses what to look for in design review to ensure that a project will meet the owner's design intent.

- The importance of ongoing construction monitoring by the design engineer. The brief offers practical in-the-field tips for designers.

Institute for Market Transformation: Promotion of Energy-Efficiency Upgrades in Long-Term Care Facilities (2000)

PECI assisted the Institute for Market Transformation (IMT) in a PG&E project to promote energy-efficient retrofit measures and operating practices among nursing homes in California. PECI participated in the following tasks:

- Development of an energy-savings guide for owners and operators of nursing homes, focusing on measures most likely to be cost-effective in existing buildings, including lighting upgrades and retrocommissioning. The guide emphasized the non-energy benefits of energy-efficiency upgrades such as thermal comfort, indoor air quality and occupant health;
- Seminars on energy efficiency and facility management. Like the energy-savings guide, the seminars contained an overview of technical options, including a thorough briefing on retrocommissioning and its intended goals;
- Two demonstration projects on retrocommissioning in long-term care facilities. PECI identified two long-term care facilities appropriate for demonstration sites: the Meadowood Nursing Center, a 30,244 square foot facility in Clearlake, California, and the Wagner Heights Nursing Center, a 45,372 square foot facility in Stockton, California. PECI technical staff then reviewed facility operations in conjunction with the facility managers, and recommended measures or operating strategies to enhance energy performance while maintaining or improving overall system function.

New Buildings Institute: California Energy Commission Field Verification Code Development (2000-present)

PECI researched the potential for field verification protocols to ensure that energy-efficient systems are installed and operating correctly under California's *Energy Efficiency Standards for Nonresidential Buildings*. PECI identified specific field verification methods for each class of equipment and solicited input on implementation processes from stakeholders in the building industry in California. We also studied the existing enforcement process and recommended ways in which the new protocol requirements can complement the existing code enforcement process. In addition, we outlined political and technical implementation issues and tools necessary for implementation of the new field verification protocols. Currently, PECI and NBI are conducting phase II of the project, which includes an analysis on candidate equipment and systems, and develop specific code language proposals to implement performance verification into the *Standards*.

Pacific Gas & Electric: Market Characterization of California Commissioning Practices (2000)

PECI executed market research to characterize California commissioning practices and provide information on how to increase commissioning services. In particular, the objectives of this project were to:

- Report on the current status of commissioning in California, including the range of services offered, methods, tools and techniques used, and types of data collected.
- Report on the methods, tools, techniques, training activities and marketing materials that are needed to grow the market for commissioning.
- Recommend ways to increase the use of commissioning and building diagnostic services.
- Estimate the energy and cost saving potential of commissioning in California.

Sacramento Municipal Utility District: Shriner's Hospital, Coroner's Officer and Crime Lab (1999)

PECI retrocommissioned the Shriner's Hospital and Coroner's Office and Crime Lab as part of the Sacramento Municipal Utility District's retrocommissioning demonstration program. The retrocommissioning process included site visits, document and controls review, testing, monitoring, and engineering analysis. A number of significant improvements were identified, energy savings quantified and implementation costs estimated. Benefits consisted of large energy savings, improved building control and indoor environmental quality improvements.

US EPA, O&M Best Practices Series (1998)

PECI researched and developed several user-friendly guidebooks to help facility managers and operators improve building O&M practices. These documents are part of the US EPA/DOE investigation into commercial building operation and maintenance practices. They include:

- *O&M Best Practices Series: 15 Best Practices,* an overview of all the documents.
- *Energy Management Systems*: *A Practical Guide,* a guidebook for the selection, procurement, installation, and operation of energy management control systems.
- *Operation and Maintenance Service Contracts,* a guideline for how to obtain best-practice contracts for commercial buildings.
- *Portable Data Loggers: Diagnostic Monitoring for Energy-Efficient Operation,* a guideline for selecting and using portable data loggers to improve facility performance and energy-efficiency.
- *O&M Assessment,* a guidebook for assessing the performance of existing systems.
- *Putting the "O" Back in O&M,* a guidebook that addresses optimizing equipment schedules, tracking performance, and incorporating tune-up practices into preventive maintenance.

PECI References

The following references may be contacted to obtain information about PECI:

Mr. Gregg Ander, FAIA
Chief Architect
Southern California Edison
(626) 633-7160

Mr. Grant Duhon
Program Manager Supervisor
Pacific Gas and Electric Company
(415) 972-5695

Ms. Nancy Jenkins, P.E.
Director – PIER Buildings Program
California Energy Commission
(916) 654-4739

Mr. Jeff Johnson
Executive Director
New Buildings Institute
(509) 493-4468 x13

Mr. John Jennings
Project Coordinator
Northwest Energy Efficiency Alliance
(503) 827-8416

Subcontractor: Architectural Energy Corporation

AEC Experience

Architectural Energy Corporation (AEC) is a leading business-to-business energy engineering firm. For the last 20 years, AEC has helped its clients to achieve and maintain peak building performance over the life of their buildings. This mission is accomplished through the application of a comprehensive and innovative suite of professional services and products – design analysis and sustainable design assistance; commissioning and diagnostic testing; utility and energy service company engineering services; energy information systems, services and data acquisition equipment; Internet services; hardware and software product development; performance evaluation; and market transformation services.

Founded in 1982 by Donald J. Frey, P.E. and Michael J. Holtz, AIA, AEC maintains an interdisciplinary staff of 40 professionals, including mechanical, electrical, and architectural engineers; architects; computer scientists; mathematicians; physicists; technicians; and research support staff to undertake complex and diverse projects related to energy, buildings and the environment. AEC's main office is in Boulder, Colorado.

AEC's professional services derive from a number of core competencies. These are:

- Monitoring and diagnostic testing
- Energy modeling and analysis
- Energy engineering
- Electronic hardware development
- Software engineering
- Code and standards

The professional services provided by AEC, and described below, combine these core competencies into unique customer solutions for a wide range of energy engineering problems.

AEC Relevant Services

Building Commissioning and Diagnostic Testing Services

AEC commissions both new and existing buildings, using its patented building diagnostic tools to find operational performance problems. AEC's commissioning process involves an active communication process among the owner, architect, engineers, general contractor and subcontractors, and building operators.

Utility and ESCo Services

AEC provides electric and gas utilities with a variety of building energy engineering services, including load research, product assessment, DSM program impact evaluation, and market transformation. Recent or ongoing projects include market transformation activities in California, evaluation of interruptible load programs in Minnesota and Colorado, and load research in Thailand.

AEC works with energy services companies (ESCos) to baseline building energy consumption and costs, diagnose building operational performance problems, conduct energy conservation measure (ECM) analysis, commission ECM measures, and measure and verify performance. ESCo engineering services have been provided on a wide range of building types, including schools, hospitals, research laboratories, military facilities, State and Local government facilities, office buildings, courthouses, and correctional facilities.

Building Science Research and Development

AEC conducts a broad spectrum of energy and environmental research and development activities for government agencies, utility companies, professional and industry associations, and private for-profit companies. Research and development activities include building energy analysis tools, automated HVAC diagnostic techniques, advanced load management and control methods, alternative cooling technologies and strategies, and building integrated photovoltaics and other renewable energy systems. AEC currently manages four programs for the California Energy Commission's PIER Buildings Program.

Since 1983, AEC has conducted research at its Commercial Kitchen Ventilation (CKV) Research Laboratory outside Chicago, Illinois. Research at the CKV laboratory has been the basis for improved design standards for commercial kitchen ventilation systems, and has advanced the understanding of commercial cooking appliance operation, heat gain from cooking appliances to the conditioned space, and appliance energy efficiency.

Product Development Services

AEC develops energy-related products, software, and services, under contract with a variety of organizations and companies. Recent or ongoing product development assignments include the following:

- Comfort Advisor Measurement Unit™ available through myFacilities.com for the in-situ assessment of indoor comfort conditions in customer facilities.
- Watt-Wiser™ wireless plug-load monitoring system for the Electric Power Research Institute to conduct load research in residential and commercial buildings.
- D-Gen Pro™ distributed generation economic screening software in cooperation with the Gas Technology Institute to assess the feasibility of microturbine, fuel cells, reciprocating engine, and other on-site power generation systems.
- Mini Optical Light Shelf (MOLS) daylighting system under DOE's Small Business Innovation Research Program. (U.S. Patent No. 6239910 B1)

Architectural Energy Corporation has developed a number of hardware and software products to support the design, commissioning, and operation and maintenance of energy efficient residential and commercial buildings. The professional products developed, marketed, and supported by AEC are listed below.

- MicroDataLogger® Portable Data Acquisition System
- MicroDataNet® Wireless Data Acquisition System
- ENFORMA® Diagnostic and Commissioning Software
- D-Gen Pro™ Distributed Generation Economic Screening Software

- REM/Design™ and REM/Rate™ Residential Energy Analysis, Code Compliance and Rating Software
- Mini Optical Light Shelf Daylighting System

AEC has demonstrated its ability to design and implement large energy efficiency programs, including a PIER-funded research program for the CEC and a countrywide load research program in Thailand. AEC was one of three organizations selected by the CEC in 1999 to manage large research contracts. The CEC selected AEC to manage another program in 2002, and again in 2003. In 1998, AEC was selected as a member of a team led by the Electric Power Research Institute (EPRI) to conduct load research in Thailand. Their role was to collect information on building characteristics, end-use electrical devices, and end-use energy consumption for all customer classes (commercial, residential, and industrial) in all parts of the country.

AEC has also done a great deal of work in California and has developed contacts in the key industries necessary for the successful conduct of this program. They have a group of engineering firms with whom they conduct projects, and many of them will likely be commissioning providers in this program.

AEC References

The following references may be contacted to obtain information about AEC:

Ms. Nancy Jenkins, P.E.
Director – PIER Buildings Program
California Energy Commission
(916) 654-4739

Mr. Gregg Ander, FAIA
Chief Architect
Southern California Edison
(626) 633-7160

Mr. Jeff Johnson
Executive Director
New Buildings Institute
(509) 493-4468 x13

Ms. Alyssa Newman
Program Manager, Commercial New Construction
Pacific Gas & Electric Company
(415) 973.4285

Ms. Lisa Fabula
Program Manager, Commercial New Construction Energy Efficiency Programs
San Diego Gas and Electric Company
(858) 636-5740

Program Administrative and Implementation Staff

Portland Energy Conservation, Inc.

Phil Welker, Executive Director

As Executive Director of Portland Energy Conservation, Inc. (PECI), Mr. Welker leads a staff of over 30 providing energy efficiency consulting and program implementation services. PECI is a leader in the development of the building commissioning field and in market transformation program implementation. Mr. Welker currently serves as the Administrator for the California Commissioning Collaborative (CCC), a group of utility, government, and private industry representatives working to develop cost-effective programs and a service delivery infrastructure to facilitate the commissioning of new and existing buildings in California. Previously, he has developed proposals for public purpose programs for the City of Portland, participated in the development of regional energy planning concepts on the staff of the Northwest Power Planning Council, and managed energy program implementation as the Director of the Idaho Office of Energy.

- Bachelor of Arts, Economics , 1977, Boise State University

Tudi Haasl, Associate Director for Commercial Services

Tudi Haasl's background ranges from institutional and commercial building operations and facility management in the private sector to installing, commissioning and auditing energy conservation measures for utilities. Her experience in the field of O & M and commissioning for commercial buildings spans 16 years. Ms. Haasl wrote a comprehensive guide on commissioning existing buildings for Oak Ridge National Labs which was published in 1998. She also managed the State of Tennessee demonstration project and program design initiative to perform existing building commissioning in state facilities. Ms. Haasl was technical lead on the US DOE/EPA cooperative agreement investigating operations and maintenance practices in commercial buildings where she lead an O & M Tune-up study on five buildings throughout the U.S.

Ms. Haasl was responsible for all site work conducted for the PECI/Southern California Edison commissioning pilot investigation which included the design and implementation of the O & M assessments, diagnostics, commissioning, and post-commissioning data analysis. She has designed and delivered numerous workshops and training programs for utility staff, commissioning providers, and operation and maintenance staff. Ms. Haasl held principal responsibility for site testing and writing the revised Bonneville *Building Commissioning Guidelines*. She works with utilities, and federal, state and local governments to develop commissioning programs that integrate with existing or planned program concepts.

- Bachelor of Education, University of Wisconsin, Whitewater, Wisconsin
- Associate Degree, Structural Drafting, North Seattle Community College, Washington
- Professional training in lighting (IES Lighting Certificate), HVAC-System Design, industrial energy audits and energy-efficient refrigeration systems.

Amanda Potter, Senior Project Manager

Amanda Potter is a Project Manager for new and existing building commissioning projects at PECI. She is currently managing three projects designed to reduce energy use in California. One is a feasibility analysis project for incorporating performance verification into the California Energy Code (as a subcontractor to the New Buildings Institute for the California Energy Commission). She is also working on three guides for Pacific Gas & Electric that help designers ensure energy efficient designs are implemented correctly in the field -- by ensuring they are clearly detailed, specified and constructed. Ms. Potter also manages a retrocommissioning market transformation project for long-term care facilities (as a subcontractor to the Institute for Market Transformation for Pacific Gas & Electric).

Ms. Potter has also worked with Nike to analyze energy saving strategies for their shoe manufacturing factories and has developed new opportunities for PECI in hydrogen and building integrated photovoltaics. Ms. Potter joined PECI in 1999 as Program Coordinator of the Energy Star® Resource-Efficient Clothes Washer program. In that role, she worked with utilities, manufacturers, field representatives, and retail stores to promote the sales of Energy Star®-qualified clothes washers. Previously, Ms. Potter researched and wrote about solar and wind systems at *Home Power* magazine and did energy audits for small businesses as an energy-efficiency consultant for PG&E. She's also taught high school physics and chemistry and worked as a technical marketing engineer for Chips & Technologies in Silicon Valley.

- Teaching Credential in Physics, Chemistry, Biology, Mathematics, Humboldt State University, Arcata, CA
- Diplome D'Etudes Approfondie in Electrical Engineering (equivalent to a US Master of Engineering degree), Ecole Centrale de Lyon, Ecully, France.
- Bachelor of Science degree in Electrical Engineering, Cornell University, Ithaca, NY

David A. Sellers, P.E., Senior Project Engineer

David Sellers is a mechanical engineer and manager at PECI working on both new and existing building performance projects. Mr. Seller's experience includes over 27 years of system design and analysis focusing on HVAC systems. Mr. Sellers' experience includes work in new and existing facilities in the commercial, industrial, institutional and health care sectors. He has extensive experience in both commissioning and technical writing. Some of Mr. Sellers' recent projects include:

- New construction commissioning of a LEED Gold facility for the American Honda Motor Company, utilizing innovative energy efficiency design strategies.
- New Construction commissioning of the Seattle Federal Courthouse.
- Retrocommissioning and project planning for the Intelligent Workplace Lab at Carnegie Mellon University.
- Publishing three design briefs for Pacific Gas & Electric Company, with a fourth underway.

Before coming to PECI, Mr. Sellers worked as an HVAC and Fire Protection engineer at Komatsu Silicon America, Inc., as a Project Manager and Project Engineer at McClure Engineering Associates, Inc as Systems Engineer for MCC Powers (now Siemens Building

Systems) and as a project engineer for Murphy Company, a mechanical contractor/design build firm. In the course of his career, Mr. Sellers has been exposed to all aspects of building design, construction and operation with a primary focus on HVAC systems.

- B.S., Aeronautics with a major in Aircraft Maintenance Engineering, 1976, Summa cum laude, Parks College of St. Louis, University

Larry Luskay, P.E., Project Engineer

Larry Luskay is a project engineer and energy solutions specialist at PECI, working on both new and existing building performance projects. At PECI, Mr. Luskay has provided recommissioning services for wide range of building types, including a 300,000 S.F hospital and a 94,000 S.F. laboratory/office building for SMUD, a high tech office complex totaling 805,000 SF for Intel, and two smaller long term care facilities for PG&E. He is currently involved in commissioning projects for Honda and for US GSA. Mr. Luskay also serves as the project lead for developing standardized procedures for recording HVAC design data for ASHRAE. The project will identify a more cost-effective manner for collecting and processing building data.

Mr. Luskay's past experience includes over 13 years providing energy conservation analysis on both new construction and retrofit projects. During that time, he performed over 120 energy analysis studies for industrial facilities, developed DOE2.1E building simulation models on 40 commercial, health care, and institutional buildings, served as the resource conservation manager for two Portland area health care facilities, and operated his own consulting business specializing in total resource conservation. His experience includes extensive fieldwork in identifying conservation opportunities, evaluating savings potential, and preparing technical documents to facilitate implementation. He also has direct experience with using metering and testing devices to measure system performance and evaluate/verify savings potential. Mr. Luskay is a registered professional engineer in the state of Oregon.

- M.S. – Mechanical Engineering , 1991, Oregon State University
- B.S. – Engineering Science, 1985, Montana College of Mineral Science and Technology

Hannah Friedman, EIT, Project Engineer

Hannah Friedman is a Project Engineer for new and existing building performance projects at PECI. Through engineering work for two Public Interest Energy Research projects for the California Energy Commission, she has investigated the persistence of new buildings commissioning measures, and she has helped to develop educational materials for the Functional Testing Guide for Air Handlers and Control System Design Guide. She also provides engineering support for a grocery store retrofit program, and works on a number of commissioning and retro-commissioning projects. Her background is in mechanical engineering, with a graduate degree from the Energy and Resources Group at UC Berkeley.

- Master of Science degree in Energy and Resources, 2001, University of California - Berkeley, Berkeley, CA
- Bachelor of Science degree in Mechanical Engineering, 1998, Iowa State University, Ames, IA

Emily Moore, Project Coordinator

Emily Moore works on a variety of research projects at PECI, including writing and editing for commercial programs. She is currently working on two Public Interest Energy Research projects: compiling a portfolio of commissioning-related products and research for peer review and developing an on-line library for the California Energy Commission's webpage. Ms. Moore is also on the PECI team coordinating the 2004 National Conference on Building Commissioning. Before joining PECI, Ms. Moore worked at Portland State University's Office of Facilities & Planning and, in conjunction with completing her master's work in planning, developed a long-range campus energy management policy and plan. She also gained valuable research and writing experience in positions with the Renewable Northwest Project and Oregon's Department of Environmental Quality.

- Master of Urban and Regional Planning degree, 2003, Portland State University, Portland, OR
- Bachelor of Science degree in Environmental Studies, 1998, University of Oregon, Eugene, OR.

Architectural Energy Corporation

Donald J. Frey, P.E., Executive Vice President

Donald Frey has been engaged in business management, project management, engineering, and energy-related research and design for over twenty-five years. Together with Michael Holtz, he founded Architectural Energy Corporation in 1982, after serving as owner of Architectural Energy Consultants, a project manager at the Solar Energy Research Institute, and Senior Engineer of Applied Science and Engineering. Mr. Frey's work has focused on the development and application of innovative building performance evaluation techniques, including the DOE/SERI Commercial End-Use Monitoring Project; ENFORMA® diagnostic, commissioning and evaluation system; and the MicroDataLogger® portable data acquisition system.

Mr. Frey recently managed a complex project conducting electric load research on residential, commercial, and industrial customers in Thailand. He developed the concept for the California Building Energy Initiative (CBEI), a Third-Party Initiative funded by Southern California Edison and the State of California. He managed the CBEI Pilot Project. He continues his involvement and commitment to performance evaluation, energy research, and diagnostic testing through research and demonstration projects with utilities and private industry clients. He is currently responsible for managing development of the MicroDataNet™ wireless data acquisition system.

- Master of Science, Civil Engineering, University of Colorado; Boulder, CO; 1975
- Bachelor of Science, Aerospace Engineering, University of Colorado; Boulder, CO; 1971

Stuart S. Waterbury, P.E., Senior Engineer

Stuart Waterbury is responsible for project management, engineering analysis, software development, and instrumentation for building energy analysis and energy services contracting projects. Projects have included HVAC diagnostics and commissioning, load research, and estimation of baseline and post-retrofit HVAC and lighting energy usage from

short-term monitoring. He has worked extensively on development and use of the ENFORMA® diagnostic system, an integrated hardware and software system for fault detection, diagnostic testing, and performance evaluation of HVAC and lighting systems. He is currently developing automated methods for detecting faults in HVAC systems, as part of a PIER-funded contract with the California Energy Commission.

Mr. Waterbury has evaluated the performance of many roof-top units and developed methods for evaluating economizer performance. He has analyzed packaged economizer performance on units ranging from small 3-ton single zone units up to "boxcar" units of hundreds of tons. Much of the results of this work has been incorporated into the ENFORMA HVAC Analyzer software.

Prior to AEC, Mr. Waterbury was employed by BDM where he was a thermal analyst for many projects in government and industry. He was also responsible for developing computer simulation models of solar thermal power plants, as well as advanced concentrating collector designs.

- Master of Science, Mechanical Engineering; Colorado State University; Fort Collins, CO; 1982
- Bachelor of Science, Mechanical Engineering, University of Nebraska; Lincoln, NE; 1977

Tracy M. Phillips, EIT, Staff Engineer

Tracy Phillips manages and assists with projects in the building energy and demand-side management. His responsibilities include project management, monitoring plan development, field installation and retrieval of monitoring equipment, energy analysis, diagnosing operational problems within commercial buildings, and performing preliminary and detailed energy studies of commercial buildings.

Mr. Phillips frequently develops DOE-2 building energy simulation models to assess proposed energy conservation measures for design assistance and building retrofit projects. Additionally, he utilizes his monitoring and diagnostic skills on existing buildings to calibrate models and uncover energy conservation opportunities. He was a member of the engineering team that conducted the California Building Energy Initiative (CBEI) Pilot Program in Southern California Edison service territory.

Mr. Phillips joined Architectural Energy Corporation in 1996.

- Master of Science, Physics; Stevens Institute of Technology; Hoboken, NJ; 1994
- Bachelor of Science, Physics (minors in Mathematics and Computer Science); University of Richmond; Richmond, VA; 1993

Erik A. Jeannette, EIT, Staff Engineer

Erik Jeannette is on the Design Assistance and Commissioning and Diagnostics teams at AEC. Mr. Jeannette's background is well-rounded in mechanical systems, control systems, energy efficient design concepts, energy monitoring and sustainable design. He offers mechanical controls expertise and control troubleshooting skills, as well as experience with control system programming and energy management design schemes. Mr. Jeannette also provides assistance to the daylighting team by offering lighting control solutions that compliment the daylighting designs.

Mr. Jeannette's background includes managing ASHRAE funded building energy research projects involving indoor air quality issues, optimizing thermal energy storage control and various other university engineering research projects. He has worked with testing of neural networks in building control systems, and whole building diagnosticians. He has also been employed as a mechanical controls design engineer where he was responsible for the design, sequences, programming and commissioning of many control projects throughout the country. Often these projects were of the design-build type requiring mechanical engineering and controls engineering skills to solve the building's comfort or energy problems.

- Master of Science, Civil Engineering (emphasis in Building Systems); University of Colorado; Boulder, CO; 1997
- Bachelor of Science, Civil Engineering (emphasis in Environmental Engineering); University of Colorado; Boulder, CO; 1995

David R. Roberts, P.E., Senior Engineer

David Roberts heads the Information Technology Team, heads the Residential Energy Analysis Software Business Area Team, and provides building energy analysis for company research, demand-side management, and energy design consulting projects.

Mr. Roberts specializes in the use of the DOE-2 building energy simulation software, software design and development, and programming in C++, FORTRAN and Visual Basic. Mr. Roberts worked on the design and creation of a series of energy analysis software products developed for a leading insulation manufacturer, and continues to develop and support AEC's residential energy analysis software products. He uses the DOE-2 program for energy and economic studies such as the New Denver International Airport and University of Wisconsin design assistance projects, and numerous commercial demand-side management evaluation projects. He is the technical lead in the ongoing development and support of Survey-IT™ and Model-IT™, a commercial building audit database and companion application that automatically generates DOE-2 simulation models for use in baseline and program evaluation studies. Mr. Roberts was a member of the project team that investigated and authored an engineering handbook on evaluation methods for demand-side management projects for the Electric Power Research Institute.

- Master of Science, Civil Engineering (specializing in Building Systems Engineering); University of Colorado; Boulder, CO; 1992
- Bachelor of Science, Environmental Resource Engineering; Humboldt State University; Arcata, CA; 1989

Michael T. Anstett, Senior Engineer

Michael Anstett, who joined the company in 1993, has been involved in computer software development for twenty years. He has an electrical engineering background, which he has applied in developing integrated hardware and software systems. He provides AEC with a strong capability in object-oriented software engineering, database design, and artificial intelligence. He is the in-house expert in software design and development. Currently working on web applications to analyze building and metering data. Mr. Anstett is responsible for directing or participating in all of Architectural Energy Corporation's software development

activities. He is AEC's lead developer for database applications, with extensive experience in most industry database platforms.

- Master of Science, Engineer with emphasis in Building Energy Systems; University of Colorado; Boulder, CO; 1992
- Bachelor of Science, Computer Science; Central Connecticut State University; New Britain, CT; 1980

John C. Wood, EIT, Staff Engineer

John Wood is on the AEC commissioning team. He also is involved in design assistance and analysis on AEC's Federal Energy Management Program (FEMP) projects and National Renewable Energy Laboratory (NREL) projects.

Mr. Wood has a marked interest in renewable energy implementation. He worked five years (1993-1998) on part time contracts with Sun Energy Systems in San Antonio building solar thermal collectors, installing, maintaining, and designing solar thermal systems. He also worked almost three years (1998-2001) with Jade Mountain in Boulder, Colorado as Appropriate Technology Access Facilitator, designing, installing, and facilitating the access to renewable energy, water conservation, water purification, energy efficient appliances, lighting, and other "appropriate technologies for sustainable living."

He has four years of Testing, Adjusting, and Balancing experience with Professional Engineers' Balancing Laboratory in San Antonio, Texas (1994-1998). This experience includes several Air Force Base projects on which he was on the commissioning team, prepared the checklists, and lead the functional performance testing.

- Bachelor of Science, Engineering (minor in Math); Trinity University; San Antonio, TX; 1992

John J. Browne, Hardware Manager

John J. Browne has more than 25 years of experience with the design and production of electronic products. He brings strong capabilities and understanding of the stringent requirements necessary to design and manufacture products which can compete in the marketplace. He is responsible for the hardware development and production of AEC's MicroDataLogger® product line. He is responsible for the design, manufacturing and testing of data acquisition systems and other scientific instruments used in AEC's research projects.

Mr. Browne has worked for a number of successful electronics companies and as Product Design Consultant. These include the OptiVideo Corporation where he was the Engineering Services Manager and Rela Inc as the Hardware Manager. At OptiVideo, Mr. Browne assisted the founder in starting the business. He developed concepts for a fiber optic switch actuator. He constructed electromechanical prototypes, prepared documentation, performed electronic and optical testing, and helped develop an automated production process. He was the Hardware Manager at Rela Inc. as well as a principal in this electronic product development firm. He was responsible for the management of the electronics laboratory, technical library, and for purchasing. He supervised technicians and subcontractors.

- Studies in Electrical Engineering, University of Colorado; Boulder, CO; 1967
- Studies in Philosophy and Theology, Holy Cross Abbey; Canon City, CO; 1964

Section VIII: Budget

The summary table below shows the program budget by category. The first column is the total budget for the three submitted proposals under the Statewide RCx Program - PG&E, SCE, and SDG&E. The second column is the budget for each utility.

PG&E

Category	Total Program Budget	Budget in PG&E Territory
Administrative	$1,206,758	$575,625
Marketing	$725,000	$345,825
Direct Implementation	$4,816,713	$2,297,572
EM&V	$250,000	$119,250
Total	**$6,998,471**	**$3,338,272**

SCE

Category	Total Program Budget	Budget in SCE Territory
Administrative	$1,206,758	$442,879
Marketing	$725,000	$266,075
Direct Implementation	$4,816,713	$1,767,734
EM&V	$250,000	$91,750
Total	**$6,998,471**	**$2,568,438**

SDG&E

Category	Total Program Budget	Budget in SDG&E Territory
Administrative	$1,206,758	$188,255
Marketing	$725,000	$113,100
Direct Implementation	$4,816,713	$751,407
EM&V	$250,000	$39,000
Total	**$6,998,471**	**$1,091,762**