Art Meets Science in a Downtown Demand Response Program

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ABSTRACT

Finding ways to avoid power blackouts has been a topic of great interest to California businesses for quite some time. One way to address this issue is the implementation of demand response programs. The Business Energy Coalition Demonstration Program is an innovative partnership project undertaken by the Pacific Gas and Electric Company (PG&E) and major San Francisco businesses and civic leaders, developed, designed, and facilitated by The Energy Coalition. Its goals are to be responsive to peak energy demand issues and to show how members can come to the rescue of overburdened power systems for the benefit of the State of California and the City of San Francisco. This paper describes how the Business Energy Coalition Demonstration Program was able to exceed an ambitious goal of 10 MW of demand response load curtailment from a cooperative group of major businesses in downtown San Francisco, California.

Background

For those who are new to the concept, demand response is the ability of utility customers to take actions to reduce electrical load at their facilities—actions taken specifically at the request of the utility companies to reduce energy use. These requests are made when peak electric demand is approaching peak electric supply.

As background, The Energy Coalition had its beginning in the mid-1970s (at the time called the Engineering Supervision Company) when, in concert with the U.S. Department of Energy, the Los Angeles Central City Association, and the Los Angeles Department of Water and Power, it created the first demand response Energy Cooperative. The success of the Los Angeles project led to Southern California Edison requesting the development of three Energy Cooperatives, and later led to a series of PG&E Group Load Curtailment Energy Cooperatives in the San Francisco Bay Area. From there, the non-profit Energy Coalition was formed and developed Energy Cooperatives in New York, Boston, Chicago, and Sweden. In the late 1990s, utility interest in load management dwindled. In 2004, PG&E decided to reintroduce the Group Load Curtailment approach and The Energy Coalition was revived.

An example of a very successful demand response concept was accomplished by the Business Energy Coalition Demonstration Program, for which PG&E and The Energy Coalition won the Peak Load Management Alliance (PLMA) 2005 Innovative Program Design Award. The success of this project, which happens to meet California's energy goals, was achieved through a convergence of art and science.

The art encompasses the "soft" skills of communication and people working cooperatively together; the science covers the "hard" technical skills of scientific analysis, process development, and implementation. Both aspects of this project were critical to its success—and one could not succeed without the other.

The art was exemplified by the combined actions of the thousands of individuals involved, including project managers from Pacific Gas and Electric (PG&E), property managers,

civic leaders, facility operators, representatives from the California Public Utilities Commission (CPUC), building tenants, the Business Energy Coalition and others—individuals who worked cooperatively on the task at hand and who had a common understanding of the program's potential benefits. The members of this partnership, much like the thousands of brush strokes on canvas required to create a fine oil painting, each added to the success of this innovative project.

The science was provided by electrical and mechanical engineers who performed building audits, created customized load curtailment protocols for each of the enrolled facilities, and oversaw the mechanisms for data collection and verification. The science also included the installation and application of telemetry services and telecommunication devices, database implementation, and more.

More about Demand Response

As a rule, demand response entails uncharacteristic or uncommon activities by customers to reduce energy use for a short period of time. Demand response options should not be confused with either demand-side management, which typically involves permanent reductions in demand, or with interruptible electric rates, which offer permanent rate reductions for the right to interrupt a customer's power usage. Demand response is also referred to as load curtailment. "Curtailable load" refers to load from equipment, machinery, or lighting that can be immediately shut off.

If a facility has discovered it can save on energy use by shutting off a portion of their lighting on an everyday basis, then that behavior does not qualify as demand response since there is no further energy reduction available for curtailment requests. Nor would there be curtailable load if a facility has retrofitted the lighting system with new, energy efficient units.

Participation in demand response programs is usually open to commercial, industrial, and residential customers who have certain minimum demand levels. Participation in a load curtailment program is voluntary. (Non-voluntary participation occurs during a blackout.) Demand response programs typically offer an incentive for participation. Payments or credits are made for each kilowatt of load shed.

The Benefits of Demand Response

There are benefits of demand response programs, and most apply to the Business Energy Coalition Demonstration Program. In part, demand response:

- Can help avoid blackouts
- Helps reduce the need for new generation plants
- Helps ensure system reliability by reducing grid interruptions and maintaining power quality
- Cuts wholesale peak power pricing, which increases dramatically when the supply/demand margin becomes too narrow
- Improves market efficiency
- Helps the environment because, through demand response, production from less efficient power plants is reduced

The Challenge of "People Buildings" and Demand Response

For typical "people buildings," such as office buildings, hotels, hospitals, banks, and the like, the process of participating in a demand response program is much different than the process of shutting down loads in the industrial sector. When "people building" customers participate, they anticipate trading energy savings for comfort and convenience, and the comfort of the people plays a critical role. However, clever engineers are able to identify procedures and measures for reducing load without affecting customer comfort and convenience. "People building" loads that can be shut down typically consist of lighting, certain motors, fans, and pumps. "Process facilities" include manufacturing facilities, cold storage, pumping applications, etc. When "process facilities" participate, they typically are trading energy savings for changes in productivity.

One special aspect of this project was that it focused entirely on "people building" facilities, traditionally more difficult to engage in demand response programs. The types of facilities that participated include banks, hotels and other hospitality facilities, college and university campuses, office buildings, real estate and property management companies, the California Public Utilities Commission, and branches of the United States Post Office.

The Project's Beginning

One of the main reasons for the success of the Business Energy Coalition Demonstration Program is PG&E's support and its commitment to make the program work. On May 3, 2005, PG&E's Account Services Department and The Energy Coalition assembled over 50 property managers and facility engineers for the launch of the program. This initial meeting was hosted by PG&E Senior Vice President Tom Bottorff and Vice President Beverly Alexander, who, with California Public Utilities Commission (CPUC) Commissioner Geoffrey Brown and The Energy Coalition's Executive Director John Phillips, introduced the project's vision and mechanics. On May 4, 2005, at a Special Projects Group meeting, John Phillips met with San Francisco Mayor Gavin Newsom, CPUC President Michael Peevey, CPUC Commissioner Geoffrey Brown, PG&E President Gordon Smith, and other PG&E senior officials to update them on the project's status and long-term vision.

The Energy Coalition (www.energycoalition.org) is a non-profit corporation that partners with utilities to help city government, businesses, students and residents to practice smart energy management. Their mission is to work with utilities to empower consumers to make informed decisions about their energy use, which is accomplished by "forging close partnerships with and among cities, utilities, businesses, schools, individuals and other interested organizations."

From the beginning of this project, The Energy Coalition was able to build trust and to enhance PG&E's relations with major downtown facility owners and managers. These participants came to understand the opportunity to achieve social and economic incentives for all parties and how they could play an important role that would benefit both the State of California and the City of San Francisco. This initial pilot program ran from July 1, 2005 through December 31, 2005, and the program has been extended through December 31, 2008.

Program Design and Features

The Business Energy Coalition Demonstration Program team devised specific program operations and the end-user incentive structure. The program design was extremely well received and provided social and economic incentives and benefits for all parties involved.

This demonstration project proved that given the appropriate incentive structure and a common philosophy, a motivated demand response group could accomplish much.

Early in the planning stages, the program team set a target of 10 MW energy use reduction for the group. Load curtailment is triggered to alleviate power system constraints for actual or forecasted statewide, regional Northern California Area, or local circuit congestion, failures and shortages throughout the program period. Specifically, the Business Energy Coalition's group load curtailment may be triggered when any of the following occur:

- California Independent System Operator (CAISO) calls a Stage 2 emergency (operating reserves are less than 5%)
- CAISO declares that PG&E's spinning reserves is below 7%
- Forecasted or actual San Francisco temperatures exceed 78 degrees
- PG&E declares a localized system emergency
- CAISO's total forecasted load is greater than 43,000 MW

These clearly stated criteria for calling a curtailment were key to the program's success—they made the calling of curtailment events easy to understand and the participants knew what to anticipate.

This program employed a creative and aggressive hybrid approach endorsed by the CPUC that incorporated Day-Ahead and Same-Day program objectives. These types of notification describe when and how a call for load curtailment might be made, depending on the energy situation.

In addition, the incentives and penalties for curtailment were similarly clearly stated. This project structure provides a balanced set of incentives and penalties that are directly tied to end user performance. The criteria for calling curtailment events are clear and easy to understand, and the incentives and penalties are also apparent. Each end user participant receives a capacity payment of approximately $50 per kW of curtailable load. If the group fails to meet the group's established Firm Service Level, the group will draw from its Shortfall Reserve Fund (supported with an additional $25 per kW) to pay ISO charges and imbalance penalties. Any outstanding balance in the Shortfall Reserve Fund will be proportionately distributed to members at the completion of the demonstration program year or carried over for an extended program. An important feature of the program is that each Business Energy Coalition member receives a comprehensive, on-site technical evaluation that provides a customized curtailment plan.

Another key to the program's success was the realization by the Coalition that users have real constraints in participating in conventional demand response programs, but that they would be able to make significant contributions by working together.

Part of what was appealing about this program was that program performance is measured based on the group's total load reduction. If one participant is not able to meet their target load-curtailment obligations (their Firm Service Level) on a specific event day, other group members could contribute more to compensate and to make sure the group as a whole met its commitment.

The Art

As mentioned earlier, this successful program design and implementation resulted from an integration of art and science. The "art" aspects of the Business Energy Coalition Demonstration Program include the activities involved with program recruitment and tenant education. The "art" encompasses the "soft" skills of communication and people working cooperatively together, of being creative and solving problems. These skills have to do with how people relate to each other and are not easy to measure or quantify.

Program Recruitment

Much of the art of this project was seen in the people skills used in recruiting program participants and the personal involvement with group members. Recruitment was performed primarily by The Energy Coalition and PG&E. Official program recruitment began with the initial PG&E meeting with property managers and facility operators. After the "feet hit the street," the 32 member facilities were recruited in a matter of 9 to 10 weeks. All signed Memoranda of Understanding to participate and are now part of PG&E's demand response portfolio. The rapid recruitment process was the result of outstanding teamwork between The Energy Coalition and PG&E.

Some buildings were easier to recruit than others. Some potential participants needed to hear the demand response story several times for it to sink in and to be convinced it was a good idea. After a few of the "big names" in downtown San Francisco signed up, others soon followed.

Getting some participants to sign up wasn't very difficult, and several of the buildings had been involved in previous group demand response programs. Most had experienced brownouts and the rolling blackouts of a few years ago and remember very well how all production came to a halt and how every business was affected. With that in mind, some building managers were more than willing to join in and to do their part to prevent blackouts from occurring in the future.

The Energy Coalition provided much of the "art" involved in recruiting participants and in the overall success of the program. They performed the important recruitment role of providing a bridge between the needs of the utility company and the desire of their customers to participate. They also provided essential hands-on management, and helped facilitate the critical communications required between all parties involved, including PG&E, property managers, facility engineers, and building tenants.

The priorities of facility engineers are different from those of property managers. Facility engineers want to know their plant systems will continue to run smoothly, and property managers want assurance they won't be receiving complaints from unhappy building tenants. The Energy Coalition was sensitive to the concerns of both. They helped facility engineers realize they wouldn't have to produce a load curtailment strategy themselves—that their facility would receive a complete building audit and professional help from experienced demand response engineers in determining what would be the best protocol for their facility.

The Energy Coalition discussed with the property managers whether to involve the tenants in the process. Certainly, informing the occupants of office buildings about the program and asking for their contribution to help make this demonstration project successful makes sense and actually improves the ability of a facility to curtail load. For these situations, the Coalition

provided property managers example text for email notices, helped organize tenant meetings, and provided posters and other forms of communication to notify tenants of curtailment events.

In contrast, hotel guests don't really need to know what's going on behind the scenes, as long as they are comfortable. The hospitality industry is typically a challenging sector to recruit for demand response.

Luxury hotels demand uncompromised standards for their guests. However, because The Energy Coalition was sensitive to their needs, hotel engineers quickly realized that this program was different and that it provided flexibility and the "back up" of other members of the group. The Coalition worked creatively with the hotel engineers, and found many ways to adjust operating systems that had little or no effect on guests, such as schedule changes to laundry operations, reduction in some ornamental lighting or signage, decorative fountain and swimming pool pumps, lights in unoccupied guestrooms and conference rooms, or selected banks of elevators. As a result, this sector enthusiastically responded—with six of the most prestigious luxury hotels in San Francisco participating in the program, the hospitality industry has become an active force in demand response for California. By contributing more than 14% of the group's total demand reduction, the Argent, Marriott, Four Seasons, Fairmont, Palace, and Hilton hotels have shown that the hospitality sector can cut energy use and still provide comfort for their guests.

Educating Building Tenants

A follow-up activity to recruitment was the education of building occupants, when requested, about why demand response is important to San Francisco and California. With somewhere between 100,000 to 150,000 people occupying the member buildings, this presented quite a challenge, but was essential for obtaining and sustaining demand reductions.

Building engineers agree that a typical office building's peak demand can be reduced by 10 to 15% without affecting building occupants. The Coalition believed that if building occupants understood the value of the program, they would be open to some changes in lighting and comfort levels, which could add up to an additional 10 to 15% in peak capacity savings. The combination of the technical measures and occupant behavioral changes is a powerful formula for success.

The Coalition made use of a variety of methods to communicate with building occupants, and each facility required a customized approach. They placed informational kiosks in the lobbies of selected sites. These touch-screen kiosks are Internet driven, multimedia displays that are used to monitor real-time energy use of member buildings, demonstrate the impact of their demand response program, and to educate about energy efficiency, demand response, and renewable energy.

Other methods included posters and other types of signs placed in lobbies and break rooms, intranet email "blasts," website newsletters, brown-bag lunch seminars, and on-site Energy Rallies facilitated by the Coalition to raise awareness. All communications reinforced earlier messages and focused on why cutting power use during critical peak periods is important, and what each individual can do to make a difference.

Tenant education helped answer some of their basic questions:

- What is demand response? How does demand response fit into the bigger picture of power generation and helping prevent future blackouts?

- What is load curtailment and how does it work? How will it affect me personally, and what can I do to help?
- Why did building management decide to participate? What are the real economic considerations and rewards? What are other rewards, other than financial?

The Science

As critical as the "art" was to the program's success, it could not have been accomplished without the "science." The "science" aspects of the Business Energy Coalition Demonstration Program include the analytical process of facility audits, the selection and installation of communications hardware, data collection and analysis, and working with facility engineering staff to make it happen.

The Building Assessment (Audit)

The Energy Coalition's engineers are an experienced team led by ASW Engineering, who has a history with the Coalition that goes back to the 1970s. In only two months, May and June of 2005, they conducted comprehensive surveys of each member facility and worked diligently with chief operators to develop load curtailment protocols. They also oversaw the installation of essential telemetry system hardware. This monumental task was completed on schedule and led the way in the delivery of 10 MW of avoided peak load capacity for the State of California.

The Coalition's in-depth load curtailment protocols are step-by-step guides that provide the details for how building operators can curtail demand and drop building load to the designated Firm Service Level when requested by PG&E.

Determining the Number of Sites

Each facility, regardless of the amount of load they could curtail, required an audit, and needed to install telemetry system hardware, which came at a fixed cost.

Therefore, in order to minimize the total number of facilities, one of the program goals was to recruit the largest facilities (in terms of square feet and peak kW energy use) with the largest possible curtailable load. Another critical factor to success was management's willingness to curtail the maximum load possible.

The Coalition had as a goal to identify a minimum load curtailment of 12% at each facility. This was based on the individual facility's annual "peak kW demand." For example, if a facility has an annual peak demand of 2,000 kW, a load curtailment of 12% equals 240 kW load reduction. Based on a load reduction commitment of 240 kW, that facility's Firm Service Level would be established at 1760 kW (peak, less their reduction amount).

The group's network annual load peak kW profile was identified based on the aggregate of the daily 30-minute kW profiles of all of the facilities during the summer months (June, 2003 through October, 2004).

"Science" Tasks

Project engineers worked hand-in-hand with PG&E to complete a series of tasks for each member facility. After a facility was approved for participation by The Energy Coalition, PG&E

provided utility information on the facility, including the number of meters and their identifiers, peak kW, the historic electric bills if available, and historic daily kW demand (24 x 7) for the months of June through September of 2004. Loads were assessed for summer and winter peak periods as well as other times.

Energy consumption output data (kWh) was provided by PG&E from utility revenue meters in the form of pulse outputs. (Some of PG&E's meters needed to be modified so that the KWh data was available in the form of pulses.) The Energy Coalition recorded all essential facility information, including facility name, address, contact person and telephone number, number of meters, and associated peak demands. Project engineers then assigned an auditor for the building and scheduled the facility audit. The auditor visited the site and worked with the site engineer to identify load curtailment protocols, recently occupied areas, new kW loads if any, and telemetry system implementation logistics. (Audit details are discussed below.) Then the implementation of the telemetry system was scheduled with an electrical contractor. The very important Facility Load Curtailment Protocol Report was created, and was submitted to The Energy Coalition for final distribution.

Building Audit Protocol

The following describes the major tasks the auditors performed at each facility. To better accomplish this task, audit manuals were created for the auditors to use to collect the information.

Before the actual audit, project engineers reviewed all available facility information. They met with the facility contact person and explained the audit protocol and process. This included a description of the telemetry system and a review of design drawings.

The audit itself involved identifying and recording general facility information. The auditor worked with the chief engineer to identify load curtailment possibilities, then determined the specific loads that may be available for load curtailment.

Next auditors performed a "Screening Audit" that provided detailed information about the facility. Before a facility can curtail load, we need to identify which loads will be curtailed and the total kW those loads represent—the higher the load, the greater the financial benefits. The amount of load reduction in a given "people building" facility depends primarily on management's willingness to sacrifice some comfort during load curtailment periods.

Screening Audit data includes such things as the number of floors in the facility, the type of Internet communications, and the location of communications systems. If there is an energy management system, auditors collect information on its capabilities and the equipment it controls.

Then, auditors complete an equipment inventory, which involves a review the electrical and mechanical drawings. The goal is to identify essential information such as the number of lighting panels in the facility, lighting panels per floor, and the number of chillers and package units. The equipment inventory also identifies the number of air handling units and whether they are constant air volume or variable air volume, and the number of air handling units per floor. Other information includes the number of motor control centers and the number of elevators and escalators in the building.

The next step is to identify the loads the chief engineer and building management are willing to curtail. This is equipment or systems that can be turned off or reduced during the load curtailment requests.

Possible load-shed opportunities include such things as reducing perimeter lighting where windows and outside light are available, selected interior lighting as in corridors and hallways and decorative lighting, the lights in the main lobby and in display areas, or lights in loading docks and storage rooms. Other strategies might include cycling or turning off supply fans, resetting room thermostats, increasing chiller temperatures by one to three degrees, turning off some exhaust fans, escalator motors or some elevators, and resetting the chilled water system supply temperature.

After the audit is completed and load shed opportunities are identified, the facility's total kW reduction is quantified.

Next, the engineers identified telemetry system implementation logistics. Then an electrical contractor installed all of the telemetry system hardware. (See below for a description of the telemetry system.) When ready, the telemetry system was activated. This occurred after the meter pulses and the gateway hardware were installed and the facility was tied into The Energy Coalition network. System tests were conducted in the buildings with facility operators (and through communications with building occupants who in many cases were directly involved and took action at times of peak demand).

Final documentation was submitted to the engineering staff so the "Final Load Curtailment" Report could be developed and submitted to The Energy Coalition.

Telemetry System

A key aspect of the "science" of this project involves providing engineering and telemetry services. Project engineers identified the telemetry system implementation logistics with the assistance of the facility operating staff.

Information gateways were installed in each of the facilities. Pulses are sent from the utility meter to the gateways, and data is then uploaded to the Internet and on to the network database. The data is then used to record and verify energy load.

The Energy Coalition employs its EnJoin 5.0 software, an interactive Energy Management System to facilitate communications and data collection, and measure the effectiveness of individual and group demand response. This software is used to notify members of a curtailment event, and monitors and tracks the energy use of individual buildings and the group performance as a whole. If one member cannot reach its Firm Service Level, a message is sent out using the EnJoin system to other members who then make up the shortfall. EnJoin 5.0 also provides a graphic representation of each member's peak load profile, a rolling seven-day average load profile, current and historical weather data, and a summary of curtailment reports including the member's and the group's Firm Service Level Factor (FSL Factor).

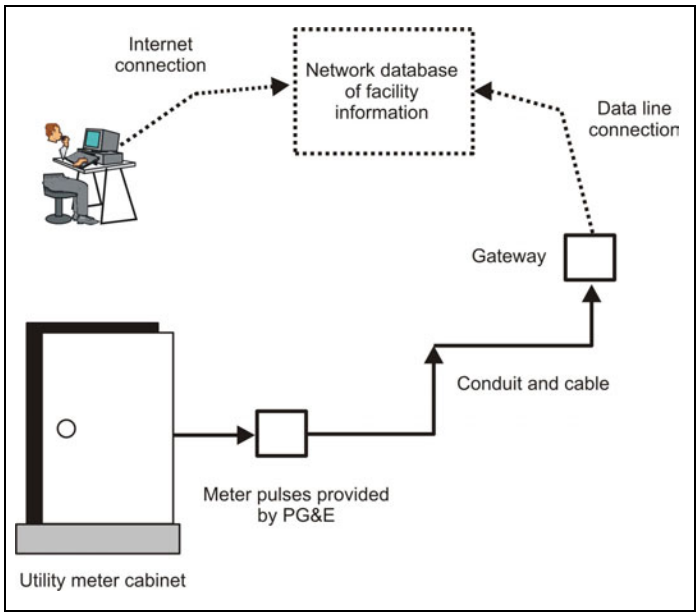
Figure 1 below shows a conceptual diagram of the telemetry system required at each facility. This system transmits the utility's meter pulses (kW) to the Business Energy Coalition network database. The data is available to the facility through Internet access.

Calls for Curtailment

Early in July, 2005 after working with every member facility, Coalition engineers identified 10.244 MW of load that could be provided to PG&E in the event of a load curtailment request—a total based on conservative estimates. As backup and just in case the engineering

assessments were too optimistic, five major additional facilities were kept on a waiting list for participation in the program.

Figure 1. Telemetry System



Source: ASW Engineering

During the month of August, 2005 the Business Energy Coalition was called upon three times to curtail load. In each of these "Energy Action Days," the group responded on time and provided projected capacity contributions beyond the program requirements. Between July 1, and December 31, 2005, seven calls were made totaling 31 hours, and resulted in an average load reduction of 14.6 MW per event.

Conclusion

As a testament to the carefully crafted project structure, the convergence of "art" and "science" and the combined efforts of the project team, the Business Energy Coalition recruited sufficient downtown San Francisco facilities to exceed the ambitious 10 MW goal of demand response capability in only a couple of months, and before the target deadline of July 1, 2005.

This innovative demonstration project showed how "people building" demand response is more than the implementation of a cold and mechanical energy rate, that in addition to the hardware and software, it requires hands-on people skills.

Communications at all levels and at every step of the project helped make it happen. Some characteristics of this program that made it successful were the clearly stated criteria for calling curtailment, clearly stated incentives and penalties, and flexibility in allocation of required curtailment within the group. Other keys to the project's success were the steps taken to keep all parties engaged and active, including the system's real-time monitoring of curtailment periods, direct financial incentives for participation, continuous feedback from the Coalition's engineering team, and quarterly meetings for building operators.

The success and the contribution of this program have been recognized—the Business Energy Coalition demand response program is being extended through 2008.