Lessons Learned in Implementing a Demand Side Management Contract at the Presidio of San Francisco

Dale Sartor, P.E., Lawrence Berkeley National Laboratory, Berkeley, California
Maric Munn, P.E., Newcomb Anderson Associates, San Francisco, California

ABSTRACT

The National Park Service (NPS) recently completed the implementation phase of its PowerSaving Partners (PSP) Demand Side Management (DSM) contract with the local utility, Pacific Gas and Electric (PG&E). Through the DSM contract, NPS will receive approximately $4.1 million over eight years in payment for saving 61 kW of electrical demand, 179,000 kWh of electricity per year, and 1.1 million therms of natural gas per year. These payments are for two projects: the installation of high-efficiency lighting systems at the Thoreau Center for Sustainability and the replacement of an old central boiler plant with new, distributed boilers.

Although these savings and payments are substantial, the electrical savings and contract payments fall well short of the projected 1,700 kW of electrical demand, 8 million kWh of annual electricity savings, and $11 million in payments, anticipated at the project's onset. Natural gas savings exceeded the initial forecast of 800,000 therms per year.

The DSM contract payments did not meet expectations for a variety of reasons which fall into two broad categories: first, many anticipated projects were not constructed, and second, some of the projects that were constructed were not included in the program because the cost of implementing the DSM program's measurement and verification (M&V) requirements outweighed anticipated payments.

This paper discusses the projects implemented, and examines the decisions made to withdraw some of them from the DSM contract. It also presents the savings that were realized and documented through M&V efforts. Finally, it makes suggestions relative to M&V protocols to encourage all efficiency measures, not just those that are easy to measure.

Background and History

All federal facilities are required by Executive Order 12902 to implement efficiency measures with simple payback periods less than 10 years. In addition, they are required to reduce energy consumption by at least 30% by the year 2005 based on a 1985 baseline. Fully occupied, the baseline energy cost at the Presidio was approximately $8 million per year. Based on preliminary analysis, potential savings of 40% or more in energy use were considered feasible for this building stock, so it was anticipated that the Presidio represented a major opportunity for energy savings.

A grant from the Energy Foundation in 1992 helped launch the development of an ambitious energy plan for the Presidio -- a plan that not only supported the overall goals of sustainability for the new national park,[1] but was intended to produce substantial cost savings to the federal government and tenant organizations. This plan was to serve as a model for sustainable reuse of closing military bases throughout the country. In September 1994, a joint resolution calling for the Greening of the Presidio was signed by the U.S. Department of Energy (DOE) and the Department of the Interior (DOI), the

[1] NPS 1993, General Management Plan

parent department for the National Park Service. The two parties agreed to work together to establish the Presidio as a showcase of energy efficiency. The Federal Energy Management Program within DOE was designated to provide support to the Presidio via the National Laboratories.[2]

Concurrently, in October 1992, Pacific Gas and Electric Company (PG&E), the serving utility to the Presidio, issued a Request for Proposals to provide the utility with approximately 20 MW of demand side management savings. The program, called PowerSaving Partners, also solicited electrical energy savings and natural gas savings. On behalf of the Presidio, NPS proposed providing 1,700 kW of on-peak period demand savings, 8,000,000 kWh of electrical energy savings, and 800,000 therms of natural gas savings. The Presidio proposal was selected for negotiations, and a contract between PG&E and NPS was signed in December 1993. The terms of the PowerSaving Partners (PSP) contract called for PG&E to make payments based on verified energy savings (performance) for a 10-year period commencing on 1 October 1994 and ending on 30 September 2004. The contract also specified a "Committed Operation Date," a date by which the program was to be fully implemented, of 1 October 1997.

Conversion of the Presidio to civilian use has been slow. The legislation to establish the Presidio Trust, the entity charged with managing the Presidio, was not signed into law until November 1996, members of the Trust were appointed in April 1997, and the executive director did not arrive until January 1998. Without the Trust in place, it was difficult for NPS to commit buildings to long-term leases or implement building renovations.

Initial Approach to Implementing DSM Projects at the Presidio

The transfer of the Presidio from military to civilian use provides an opportunity to implement energy efficiency projects in conjunction with building renovation and tenant improvements. This situation differed from the other PSP program participants, who implemented DSM projects in occupied buildings, and put the implementation of the projects at the Presidio on a much lengthier schedule than would have been true in a typical retrofit situation.

Four major impediments to installing DSM measures were identified:

1. Lack of knowledge of energy-efficiency opportunities.
2. Higher first cost to include energy system upgrades in the renovation projects.
3. Building electrical-energy consumption is not metered so tenants pay a fixed utility cost based on the amount of leased area.
4. Short-term leases.

These impediments were addressed in several ways. First, recommendations were incorporated into the guidelines for tenant-financed building renovation that would result in a substantial improvement in energy efficiency.[3] Second, an effort was initiated to develop an Energy Savings Performance Contract (ESPC) with an Energy Service Company (ESCO) who would finance and implement DSM for tenants on a performance contracting basis. The intent was to have the measures installed by an ESCO who would then be paid over time with some combination of tenant contributions and DSM program payments. Finally, the NPS anticipated changing the electrical service to the site so that the utility would take ownership of the distribution system. This would result in each facility having its own meter and each tenant being responsible for its own electrical bills. Energy

[2] Sartor et al. 1996, Designing an Environmental Showcase

[3] Warner, Sartor & Diamond 1997, Tenant Guidelines for Energy Efficiency

savings would therefore directly reduce the tenants' costs. Long term leases were also expected once the Presidio Trust management was established.

Final Approach to Implementing DSM Projects at the Presidio

When it became apparent that buildings at the Presidio were not going to be leased to tenants as quickly as originally projected, most of the efforts to implement energy-efficiency projects were postponed. Efforts were concentrated on the buildings that were being renovated by tenants, as well as the replacement of the Letterman Complex central boiler plant with distributed boilers in each building.

Work with tenants came mostly in the form of design assistance and review, and as mentioned above, the production of energy efficiency guidelines for tenant-rehabilitated buildings. DOE through its National labs, Lawrence Berkeley National Laboratory and the National Renewable Energy Laboratory (NREL) provided significant assistance.[4,5]

Measurement and Verification Requirements

At the same time as the design assistance programs were being implemented, measurement and verification plans were developed for the projects. The original DSM contract between NPS and PG&E called out fairly specific M&V protocols for lighting, adjustable-speed drive electrical projects, and gas saving projects. The DSM contract had M&V guidelines for other electrical saving projects, but final M&V plans were to be determined on a case by case basis. This flexibility was required at the time of the contract signing because it was not yet clear which specific measures would be included in the scope of the contract.

In 1994, after the DSM contract was approved, PG&E issued a guide to preparing M&V plans. This document incorporated concepts and methods specified in "Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand Side Management Programs" as adopted by the California Public Utilities Commission in July 1994. The document provided clarifications on preparing M&V plans for the lighting projects included in the Presidio's implemented measures. However, the document did not provide specific guidelines for preparing M&V plans for boiler replacement and chiller replacement projects installed by NPS. This lack of clear direction led to lengthy negotiations on the project specific requirements. Ultimately the M&V implementation costs became so excessive that all but two projects were dropped from the DSM program. The most successful M&V implementation, as well as the most successful project overall involved the natural gas savings resulting from the replacement of an aged central boiler plant with new boilers distributed in individual buildings. The M&V plan was highly cost effective, involving the simple collection of natural gas utility billing data.

It should be noted that PG&E's position was to hold the Partners in the PSP Program to the same level of accuracy that the PUC held for the utility. To avoid risk, PG&E interpreted the requirements conservatively. This placed the entire risk of not achieving energy savings on the partner rather than the utility. Had it not been for the high cost of measurement and verification, this policy makes sense. Unfortunately such a policy leads to a small set of retrofits that are easy (cost effective) to measure and verify. The unwillingness to share risk eliminates technically viable retrofits that are

[4] Sartor et al. 1996, Designing an Environmental Showcase
[5] Brown et al. 1997, Guidelines for Sustainable Building Design

difficult to measure accurately. This is especially true on small and complex building projects where the statistically valid sample size is close to the entire population. In addition the "transaction" and mobilization costs on these small projects are also high. The fact that M&V requirements drive the selection of energy conservation measures is a major policy issue that must be addressed at the regulatory level. A building owner entering into a performance contract with an energy services company is much more likely to share risk with the contractor (especially risks that the contractor cannot control) and accept an M&V strategy that proves the capacity to save rather than proving the savings itself.

The next section discusses the specifics of the projects developed and the M&V required.

Specific Presidio DSM Projects

Despite a slow rate of building renovation, several Presidio energy efficiency projects were implemented. Two projects were submitted for DSM payments: the installation of high efficiency lighting systems at the Thoreau Center for Sustainability and the replacement of an old central boiler plant with new, distributed boilers. Two additional projects were accepted by PG&E and implemented, however they were ultimately withdrawn from the DSM program by NPS because the required M&V efforts were too costly. These projects involved the addition of a small, high-efficiency chiller to serve low load conditions in the Letterman Army Institute of Research (LAIR) Building and installation of high-efficiency lighting systems at the Golden Gate Club and YMCA buildings.

Installation of High Efficiency Lighting Systems at the Thoreau Center for Sustainability

The Thoreau Center for Sustainability moved into four buildings of the old Letterman Army Hospital (comprising approximately 70,000 square feet) after major tenant-financed building renovations. Included in the renovations were the replacement of old, inefficient lighting and control systems with new, highly efficient systems. The new systems included T-8 fluorescent lamps and electronic ballasts, compact fluorescent fixtures, low voltage halogen systems, and controls including occupancy sensors, timeclocks and dual switching. Combining fixture upgrades with lighting controls yields deep cuts, but the second measure (depending on the order of evaluation) is much less cost effective than the first. Typically either will save 40%, however, when combined, the savings is 64%. Therefore the "second" measure only saves 24% of the original baseline. In the case of the Presidio deep cuts were desired and "cream skimming" was avoided. In addition, much care was taken during the building renovation to retain the historic daylighting features of the building, allowing occupants to turn lights down or off with the dual switching controls during many of the building's occupied hours.

Annual savings of 178,585 kWh (58% reduction), and 61 kW (67% reduction) were achieved based on measured data. The projected Total DSM payment is $140,000.

Since this was the first DSM project implemented at the site, several approaches to documenting the project's energy savings through measurement and verification (M&V) were explored. The fixture retrofit savings were documented in detailed pre- and post-installation audits that quantified the connected load through complete fixture counts and data on individual fixture electrical draws. The project also included several lighting control measures, so a determination of post-installation run-time hours was required to quantify post-installation energy consumption. Pre-installation run hours were agreed to in the DSM contract.

The simplest approach would have been to install run-time meters on a sample of lighting fixtures or circuits. Because dual-level lighting controls were installed in many areas, it was believed that the run-hour approach would not capture the savings involved with running fixtures at partial output. Furthermore, due to the large number of usage types and variety of configurations, the required sample size approached the entire population (all circuits).

The next approach explored was to place demand (kW) recording meters on a sample of fixtures or circuits. However, the variation in run-hours from fixture-to-fixture is highly variable with the installation of occupancy sensor controls. Therefore, PG&E again required a large sample size for monitoring occupancy sensor projects in order to obtain the confidence levels required for documenting project savings. After examining the building's electric circuits, it was determined that metering all lighting circuits, excluding exterior, exit and task fixtures, would be the best approach. Several panels held exclusively lighting circuits, allowing the entire panel to be metered. In all, 4 panels and an additional 35 individual lighting circuits were metered.

The cost of purchasing recording watt-meters and recording ammeters was compared and it was determined that the amp-hour metering would cost approximately 60% of the cost of watt-hour metering. Therefore, the final metering protocol started by developing a correlation between circuit amps and watts through the use of a hand-held power meter. Then the amp-hours at the circuit or panel phase level were monitored for a one month time period, and a spreadsheet was utilized to calculate kW and kWh for the metering period. Finally, annual estimates of performance were projected from the metered data.

The total cost of purchasing metering equipment and setting up the initial year's M&V effort was approximately $27,000; roughly $12,000 for metering equipment costs and $15,000 in outside labor costs. These costs do not include internal NPS and DOE/LBNL administrative and labor costs. This is well above the annual DSM payment, which averages $14,000 per year over the 10-year contract period. It was anticipated that the cost of the metering equipment could be amortized over other lighting projects at the site, so the equipment was purchased. In addition, the second year metering cost of $7,567 (contract proposal -- not including in-house labor and administrative costs) was considerably lower than the initial year, since the physical setup had been finalized and the software for data manipulation had been developed.

One of the lighting design issues revealed during the post-installation metering process was that some potential savings were missed because occupancy sensor controls were installed in place of wall switches in some areas of the buildings. Although this resulted in a lower installation cost, the building's occupants complained that they had no way to turn off the overhead lighting fixtures on sunny days when they were content with daylighting levels of light. This resulted in more energy use than was required and a decrease in occupant satisfaction. It is strongly recommended in future lighting design efforts to include wall switches in conjunction with occupancy sensor controls.

After analyzing the first year's data, it appears that the lighting controls accounted for approximately 25% of the project's kWh savings and 36% of the project's demand savings. The extra costs incurred to meter savings due to the lighting controls does not appear to justify the incremental DSM payments (although the controls met expectations). During the lengthy negotiations, the PG&E program manager suggested that we not submit the lighting control system under the DSM program, but instead submit it under their normal rebate program. In retrospect this should have been more seriously considered. Clearly M&V requirements can significantly impact the selection of retrofits, and their cost effectiveness. Unfortunately, the "standard" M&V protocol for lighting under the DSM program measures on-time. Therefore, if we had chosen to install occupancy sensors, and not included

them in the DSM program (therefore avoiding the high M&V costs), the reduced operating hours measured would have reduced the payments received for the fixture upgrades.

Overall, the M&V costs for this project (over the 10-year contract period) will exceed 50% of the retrofit construction costs for a typical fixture and control project. If a dollar value were put on the internal NPS and DOE/LBNL labor and administrative costs, the M&V costs would likely exceed the DSM contract payments. These actual costs are much higher than the reported industry averages of 5 to 10% of the construction cost, and are likely due to the small project size and large number of room uses and configurations. Small populations preclude the use of reasonable sample sizes to achieve the accuracy's required for occupancy sensor based lighting controls.

M&V of this sort is clearly not cost effective. In some cases, particularly with HVAC systems and controls, M&V can provide a useful "continuous commissioning" function. In such cases, the M&V may aid in diagnosing problems, and optimizing performance. That is not the case here; the M&V adds little value other than to prove to PG&E what the savings are. The risks associated with inaccurately estimating operating hours is hardly worth these high costs. Further, the policy issues involving M&V driving what retrofit measures are undertaken (those whose performance are easy to measure) must be seriously considered. The M&V requirements used by PG&E encouraged cream skimming -- the retrofit of lighting fixtures only, without the implementation of lighting-control systems.

Replacing an Aged Central Boiler Plant with New Distributed Boilers

Many buildings in the vicinity of Letterman Hospital received steam from a central boiler plant. The steam distribution system was very old and in a state of disrepair -- not unlike many found throughout the country at military bases, university campuses and other institutions. Calculations of building thermal loads indicated that almost 50% of the energy supplied by the central steam plant was being lost from the antiquated distribution system. The NPS and various tenants have installed small, high efficiency, distributed boilers in all the occupied buildings that were served by the central steam plant, allowing the steam plant to be decommissioned.

Annual savings of 1,084,616 therms (60%) were achieved based on measured data. The projected total DSM payment is $3,969,700.

The M&V plan for this project called for using utility gas meters to compare pre-installation and post-installation gas consumption. Although negotiations were difficult at times, the ultimate M&V plan is reasonable and cost effective. Some initial work was required to normalize base year central plant gas use data to average 30-year weather conditions. Work was also required to estimate gas consumption for the buildings included in the project that were not occupied by the project's commissioning date, including those that are to be demolished. It was clear that claiming gas savings from vacant buildings was not appropriate, so provisions had to be made to adjust the savings calculations. These are the type of issues not addressed in standard M&V protocols. The solution consisted of analyzing gas consumption for other similar but occupied buildings either at the Presidio or in the San Francisco Bay Area and developing gas use indices to project baseline gas consumption for presently unoccupied buildings on the steam loop. Once that work was completed, the M&V efforts for this project consisted of collecting gas bills, checking them for reasonableness, adding the allowances for unoccupied buildings, and comparing the total to the baseline gas use (historic use at the central plant). This function will eventually be handled by the accounting office with minimal engineering input. This project has a high rate of return with low M&V and administrative costs.

The actual measured savings of 1,084,616 therms in the first year was 22% more than the estimated savings of 888,861 therms. In addition, NPS reaped significant operation and maintenance savings. These savings were possible because central heating plants with large boilers require on-site engineers 24 hours per day, whereas small boilers in individual buildings require no on-site attendants and only occasional maintenance. Combined with the DSM payments, these savings yielded a payback under two years for a major capital improvement. All parties are happy with this project, and it is anticipated that the resulting DSM contract payments will be re-invested in other energy efficiency projects at the Presidio of San Francisco.

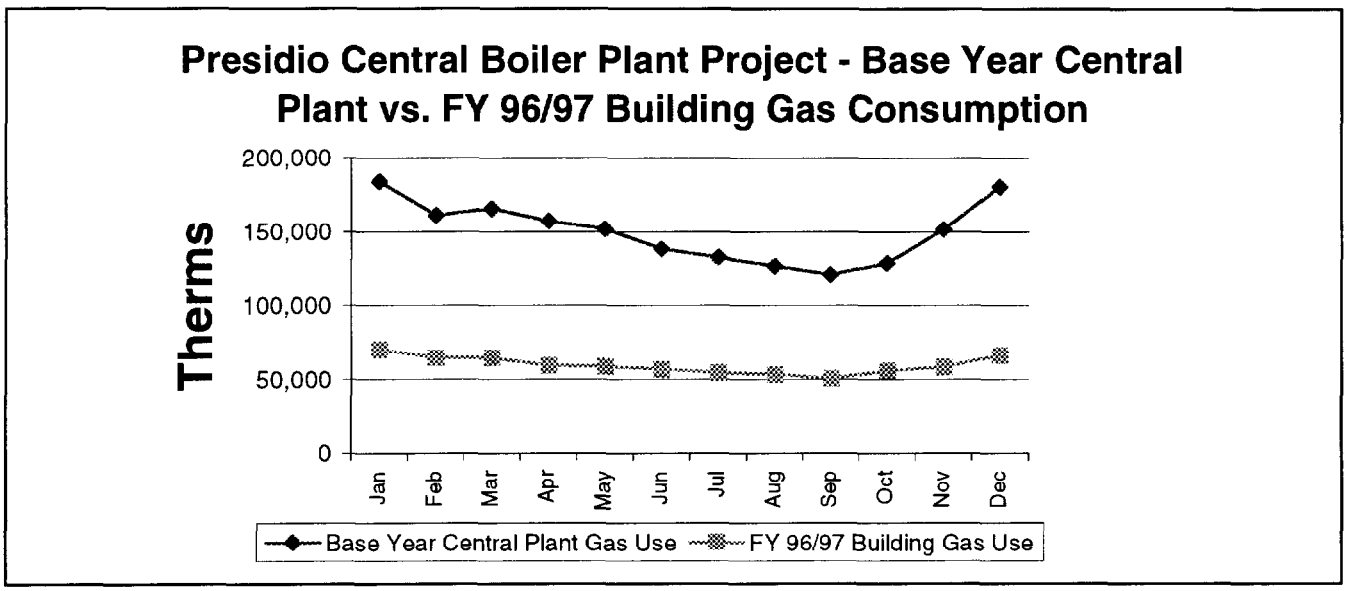

Figure 1. Gas Energy Consumption in the Letterman Complex

Adding a Small, High Efficiency Chiller to the Letterman Army Institute of Research (LAIR)

Other HVAC energy efficiency projects implemented at the Presidio did not share the success of the Boiler Plant Replacement project.

Prior to the Army's departure, the LAIR Building housed energy-intensive laboratory and computer equipment. The building's cooling loads were served with three 535-ton capacity, centrifugal chillers -- oversized even at that time. The large chillers operate at very low partial-load efficiencies, especially now when the building is not fully occupied. This project added a new chiller to the LAIR's chiller plant. This chiller has a capacity of 200 tons and has a much higher efficiency than the existing chillers. It is anticipated that the new chiller will serve the building's loads the majority of the time with current occupancies, and will contribute to the overall chiller plant efficiency when the building becomes fully occupied.

Annual savings of 56,476 kWh and 45 kW were estimated.

A draft M&V plan was prepared for this project and initial discussions with PG&E were held to determine the level of monitoring effort required. After lengthy negotiations, it was determined that the M&V costs over the eight-year project life would significantly exceed the estimated $61,000 in DSM payments. Consequently, the project although implemented, was withdrawn from the PG&E program. The expense of implementing M&V for this project was primarily due to the large amount of

data analysis required continuously during the contract period. It would appear that the only cost effective way to have monitored savings for this type of project was to have performed one-time cooling-load and chiller-performance measurements and then agreed upon these parameters for the life of the contract. This was not appropriate for this specific project because the building's cooling loads were expected to change over time as the building became more fully occupied.

Installation of High Efficiency Lighting Systems at the Golden Gate Club and YMCA Buildings

The NPS renovated the Golden Gate Club, a 24,000 square foot facility, to serve as a conference center. The renovation included upgrading the old, inefficient lighting systems to highly efficient systems. The design included new T-8 lamps and electronic ballasts, compact fluorescent fixtures, and occupancy sensor controls. This building has been designated by NPS as an energy efficiency showcase project. Similar retrofits were implemented by the YMCA who leased three Presidio buildings totaling 46,800 square feet: two gymnasiums and a swimming pool. These buildings were renovated and the old, inefficient lighting systems replaced with high-efficiency systems in selected areas. At the time the pre-installation audit was completed for the YMCA, it appeared that there was significant potential for lighting savings in these facilities. However, due to wiring problems in some areas of the main gym, not all the anticipated lighting fixture retrofits were accomplished.

Total annual savings of 95,401 kWh and 20.8 kW were estimated for theses projects. The projected total DSM payment was $62,251.

It was anticipated that the costs to implement M&V for the Golden Gate Club and YMCA projects would be approximately $6,000 per year plus internal administrative and labor costs. The sum of these costs exceeds the estimated DSM payments so it was decided not to include these projects in the program. Similar to the Thoreau Center, the M&V cost for these projects was excessive primarily due to the small size and complexity of the buildings and the inclusion of lighting controls as an efficiency measure. The ongoing M&V activity although modest (less than 1.5 person days per month) is excessive for these type of small projects.

Conclusion

The financial centerpiece for the greening of the Presidio has been an innovative pay-for-performance DSM contract with the utility company, PG&E. Under the contract PG&E will pay NPS for actual savings achieved over a ten year period. The gas savings has been a spectacular success, far exceeding expectations and resulting in close to $4 million in expected DSM payments to the Park Service over the contract period. Measurement and verification of gas savings was simple and cost effective. The DSM contract payments for electrical savings did not meet expectations for a variety of reasons. These reasons fall into two broad categories: first, many anticipated projects were not constructed, and second, some of the projects that were constructed were not included in the program because the cost of implementing the DSM program's measurement and verification (M&V) requirements outweighed anticipated payments.

The first category, projects that were not constructed, was largely unavoidable. By the implementation deadline set forth in the DSM contract, only a fraction of the Presidio's building stock had been leased to tenants. This was largely due to delays in the federal legislative process in setting up the Presidio Trust, the entity charged with managing the Presidio. Without the Trust in place, the

NPS was not able to commit buildings to long-term lease arrangements or implement significant building renovations.

The second category of projects, those constructed but not included in the program because of M&V expense, holds some lessons for future DSM contracting efforts. Specifically, the projects in this category included: a chiller installation at the Letterman Army Institute of Research (LAIR) and lighting fixture replacements, retrofits and controls at the YMCA buildings and the Golden Gate Club.

Valuable lessons were learned through the projects that were implemented. One lesson was that metering individual circuit amperage or status (run-time) over time to estimate savings due to lighting controls is labor intensive and an expensive procedure. The number of samples required to meet utility-required confidence levels is high especially in small and complex buildings. Furthermore, the use of lighting controls undermines standard protocols for measuring fixture retrofit performance (run-time) by decreasing the hours of operation -- an added disincentive for controls. Including controls (in conjunction with fixture upgrades) in DSM (or market transformation) programs may only be cost effective if performance measurement and verification (M&V) can be based on smaller sample sizes, one-time short-term metering, or stipulated hours of operation.

A second major lesson was that the M&V for chiller replacement projects is very expensive, especially if on-going documentation is required. It would be far more cost effective to develop cooling load profiles based on stipulated values, short term tests, or at most one year of monitored data, rather than to require continuous monitoring for the full contract term. This is especially important for small chillers, where M&V costs become disproportionate to the construction cost and energy savings.

We urge designers and implementers of DSM bidding and standard-offer programs to encourage all efficiency measures, not only those that are easy to measure. M&V protocols should be flexible and reasonably applied. M&V costs for each measure should be capped at a modest percentage of the incentive payments. This would require compromise on standards of accuracy especially for small, complex projects, but we feel this is a reasonable trade-off.

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World Wide Web Sites

U.S. Department of Energy's Energy Efficiency & Renewable Energy Clearinghouse (EREC): http://www.eren.doe.gov/erec/factsheets/erec.html

U.S. Department of Energy, Federal Energy Management Program (FEMP): http://webdevvh.nrel.gov/femp/

National Park Service: http://www.nps.gov

The Presidio Alliance has a web site at: http://www.presidio.org

Lawrence Berkeley National Laboratory, Center for Building Science: http://eande.lbl.gov/CBS/eXroads/EnergyXroads.html