9 Appendix B: Site Reports

1. SITE 1: YOSEMITE NATIONAL PARK, CA

Site contact:	Diane Mansker
Contact Date:	Oct.29, 1999 via conference call
Documents reviewed:	Initial proposed M&V plan and final DO M&V plan, FEMP team comments and correspondence regarding M&V plan, Schedules H1-H7
Schiller Contacts:	David Jump and Ben Gallant

1.1. Project Motivation

When Super ESPC contractor BMP approached Yosemite about energy savings opportunities in the park, facilities staff already had a good idea of the importance of M&V. They also had a strong interest in saving energy, and a fair idea of where some energy savings opportunities might exist, and of where certain equipment upgrades were most needed. Other contracting means were available, but with BMP pre-approved through the SuperESPC, and DOE contracting assistance and technical review freely available, a SuperESPC contract seemed by far the simplest means of achieving these goals. Also, on a grander scale, the National Park Service (NPS) was interested in test driving the SuperESPC, and Yosemite provided one of the earliest opportunities.

From a cost savings standpoint, this project is driven by the voltage upgrade, which has no energy savings but constitutes 58% of the cost savings. However, energy savings were still a significant agency motivation for this project, and for this reason M&V of the guaranteed savings was important to the Park. Diane “Pookie” Mansker, the technical representative for the Park, was familiar with FEMP M&V procedures, having taken a class on the subject prior to the beginning of the DO negotiation process, and she worked to make sure M&V issues were not overlooked.

1.2. Project Description

Of eleven ECMs considered, seven were chosen based primarily on their payback period. The measures that were dropped consisted of three boilers and one chiller, all with simple paybacks over forty years. This, rather than ease or difficulty of M&V, was the major factor in measure selection. One boiler replacement—in the Park Visitor’s Center—remained in the DO because it was a high priority item for the Park, even though the savings were small and the payback was long. Table (1) shows the ECMs chosen in the final delivery order. No O&M savings were claimed, but the Voltage Upgrade savings are based purely on rate structure changes, so for the purposes of this report.

Table 1: Summary of ECMs

Measure	Cost (total)	Energy Cost Savings (annual)	Total Savings—incl. Rate change savings (annual)	M&V Method
Boiler Replacement – Visitor's Center	$98,258	$1,206	1,206	A
Time of Day Controls	$7,198	$3,929	$3,929	A
Conversion to VAV	$47,196	$7,223	$7,223	B→A
Economizer Retrofit	$13,233	$3,941	$3,941	A
Lighting	$94,165	$8,436	$8,436	A
VFDs	$130,500	$9,471	$9,471	B→A
Voltage Upgrade	$193,985	$0	$48,157	A
Total	$301,037	$34,206	$83,363	

Savings for three of these ECMs—Time of Day Controls, Conversion to VAV, and Economizer Retrofit—are based on a DOE-2.1E computer simulation of the El Portal Wastewater Treatment Plant. Data from post-installation metering of the system air-handler will be used to true up the model and associated savings calculations after one year of operation. After the first year, savings will be stipulated based on the first year true-up model. Thus, a combination of measured and stipulated savings is used.

1.3. M&V Development Process

No M&V plan was provided in the initial proposal, but M&V was a point of discussion from the inception of this project due to Yosemite's interest in verification. However, the Park also wanted to avoid entering into a long contract. To keep the cost of M&V down, BMP's initial proposal included very little metering to verify savings, relying mostly on engineering calculations and computer modeling with estimated inputs.

Early in the project, NPS secured $12,000 from the DOE to install continuous kW metering on two of the proposed ECMs— the VAV conversion and VFDs at the wastewater treatment plant. Since the NPS was performing the metering, this saved costs and kept the contract term short, while allowing for a more rigorous M&V strategy on these higher-savings measures. Without this funding, the M&V plans would have used exclusively Option A approaches, based on engineering calculations with little or no measurements.

M&V plans for the other four ECMs use an Option A approach based on engineering calculations and a few spot measurements. With this approach, reviewing the validity of assumptions was especially important, since stipulations based on these assumptions will determine savings for the rest of the contract. For example, the lighting savings calculation uses operating hours based on staff interviews, an assumption which experience shows to have a certain amount of uncertainty associated with it.

A DOE2.1E computer simulation is used to calculate savings for three measures—Time of Day Controls, VAV Conversion, and Air Side Economizer. The initial proposal contained little detail on the assumptions used to build this model. The FEMP review team noted this[1], and BMP included a “Modeling Assumptions” section in the final DO. Among other assumptions, most equipment efficiencies in the building are estimated based on past experience of similar systems, or use manufacturer data. Weather data is acquired from the Typical Meteorological Year (TMY) file for California Climate Zone 16, which spans from the Oregon border to the south central Sierras.

In the M&V plan development process Yosemite (with help from the FEMP team) pushed to verify some of BMP’s assumptions, but with so many Option A approaches and often so little associated savings, constraints on time and resources limited the opportunity to do this. In the end, other DO issues, such as term of contract and measure selection, took precedence over M&V negotiations.

1.4. Use of M&V Guidelines

The M&V plan for the Yosemite project uses a variety of techniques to calculate and verify savings. Engineering calculations, spot measurements, billing analysis, computer simulation, and long-term metering all are used. Most variables are assumed or estimated and a few are measured, but ultimately all performance and usage parameters are stipulated. After the first year, persistence is addressed by annual checks that the installed equipment is still functioning as designed.

For the three ECMs that rely on DOE2.1E computer simulation, the M&V plan draws some points from the FEMP Guidelines but generally falls short of the recommended rigor. In calibrating a model, the Guidelines suggest a monthly Mean Bias Error (MBE) of less than 7%, where the Yosemite simulation differs from utility bills by over 20% for some months. Only one month has an MBE within the recommended limit. It should be noted that the Guidelines allow for an agency and ESCO agreeing on looser calibration criteria, but no such criteria seem to be explicitly defined in the M&V plan.

Some other measures, such as lighting, have simple M&V approaches as described in the Guidelines, and some, like boiler replacement, are not addressed in the Guidelines. The following is a more detailed explanation of the M&V approaches.

Boiler Replacement

This ECM accounted for 4% of total energy cost savings, 14% of therm savings, and 0% of kWh savings

This ECM has the least savings and the longest payback. Since the boilers represent the only diesel fuel consumption in the Visitor’s Center, one year’s worth of billing data are used to determine the baseline fuel consumption. The baseline boiler’s efficiency is spot measured and compared against the manufacturer-specified efficiency of the new propane boiler to determine the energy savings. Cost savings calculations take into account the pricing difference between the two fuels. No spot measurement of the manufacturer efficiency or examination of future utility bills is proposed. If the billing data came from a colder than average year, or if the new boiler operates below design conditions, the estimated savings may not be realized, but again these savings are small to begin with.

[1] Tim Kehrli, “Comments on Bentley Proposal for Yosemite National Park,” 10/16/1998

1.4.1. Time of Day Controls

This ECM accounted for 11% of total energy cost savings, 32% of therm savings, and 6% of kWh savings.

Along with the VAV Conversion and Air Side Economizer, this measure relies on a DOE-2.1E simulation to calculate savings. It is difficult to assess the validity of a computer model without detailed information on the sources of input data and extensive experience in creating and calibrating such models. BMP provided a Modeling Assumptions section separate from the M&V plan to outline some of this information. Typical Meteorological Year weather data from California Climate Zone 16 were used. Most parameters are estimated/assumed without measurement, including percent outside air, supply fan motor horsepower, boiler efficiency, minimum and maximum supply air temperatures, lighting power density, and plug loads. Chiller efficiency is based on manufacturer data. As part of the M&V for the VAV conversion, a metering of the air handler motor will be performed.

An Option A approach is used and it is unclear whether savings estimates will be adjusted after post-installation monitoring data are collected. Nevertheless, Time of Day Controls represents the second smallest savings in this project, and the usage (if not the performance) is at least well documented.

1.4.2. Conversion to VAV

This ECM accounted for 21% of total energy cost savings, 22% of therm savings, and 20% of kWh savings.

This ECM also relies on the computer simulation, but the M&V plan clearly states that one-year of post-installation kW monitoring on the supply fan will be used to true-up the savings. The monitoring will be performed by Yosemite staff and the data provided to BMP team for analysis and reporting at the end of the first year. These data will then be fed into the DOE2.1E model to calculate savings. This approach is referred to as “Option B” in the M&V plan, though savings are stipulated for all years after the first year, so a B→A designation is used in this report. The kW metering on the air handler provides verification of savings on that motor, but heating and cooling savings associated with this measure remain stipulated as calculated by DOE2 model.

1.4.3. Economizer Retrofit

This ECM accounted for 12% of total energy cost savings, 32% of therm savings, 2% of kWh savings)

The third and final computer simulation/interactive savings measure, the economizer retrofit, is also vague about whether savings will be trued up with the first year’s data. In the simulation the system is modeled as an integrated economizer with a high limit temperature of 72°F and a low limit temperature of 45°F. Like the other building simulation measures, a percentage of total building savings associated with this measure is calculated by performing an isolated run of the simulation and comparing it with isolated runs for the other ECMs. This percentage is then applied to the total savings in a combined run. Persistence is addressed by inspection of the installed equipment at the end of year one, and by annual reporting by Yosemite staff to BMP thereafter.

1.4.4. Lighting

This ECM accounted for 25% of total energy cost savings, 0% of therm savings, and 31% of kWh savings.

Lighting represents the second largest energy cost savings in the project. Yosemite was already familiar with the merits of lighting improvements, as the majority of the park was already retrofit. An Option A approach is used, with stipulated hours of operation and manufacturer rated fixture wattages.

Usage monitoring is often recommended to increase lighting savings confidence. However, BMP's usage estimates are detailed—with 22 different usage groups defined—and conservative—with most groups under 2600 annual hours. Thus, a no measurement approach seems like an appropriate low-cost application of the FEMP Guideline's LE-A-01 method.

1.4.5. VFDs on WWTP Aerators

This ECM accounted for 28% of total energy cost savings, 0% of therm savings, and 42% of kWh savings.

This ECM consists of replacing existing aeration pump motors at the El Portal Waste Water Treatment Plant with high efficiency motors and Variable Frequency Drives. The pumps currently operate continuously, but after retrofit the VFDs will adjust aeration based on input from dissolved oxygen sensors in the waste water basins. This ECM represents the largest energy savings in the project and an Option B→A approach is used, with continuous true-power metering on the aerator pumps provided by NPS. After one year of monitoring, savings will be stipulated based on the results.

Even though this measure represents the largest energy cost savings, it is important to note that it is still dwarfed by the cost savings of the voltage upgrade, which is five times as great.

1.5. Examination of Risks Associated with M&V Plans

Potential risk is proportional to cost savings. In this project the largest share of the cost savings are rate change savings from the voltage upgrade, so the only risk there is the potential for future rate structure changes. The likelihood of such a change is beyond the scope of this M&V analysis. The next three largest savings measures are:

- VFDs on Aerators
- Lighting
- Conversion to VAV

Two of these ECMs—VFDs on Aerators and Conversion to VAV—are targets of actual measurements, where elsewhere in the M&V plans most values are estimated or assumed. This shows a good application of M&V effort, reducing uncertainty through metering of higher savings loads. It is important to remember that this approach would not have been possible without DOE funding of measurement equipment.

These two "Option B" measures change over to stipulated savings after one year of measurement. Thus, risk for future performance is transferred back to the park, protecting BMP from changes is usage that could diminish savings, but also somewhat degrading the "performance" aspects of the contract. For the VFDs at the wastewater treatment plant this may be appropriate. Assuming most of the savings come from the VFDs (and not the increase in motor efficiency), savings could be substantially reduced if oxygen demand increases in the future. Since such an increase in load at the WWTP is entirely out of BMP's control, this seems like an appropriate distribution of risk.

The VAV Conversion is one of the measures whose savings are calculated in the DOE2.1E model. Since most of the savings associated with this measure will be on the air-handler motor that is being metered, much of the risk is transferred away from NPS (at least for that first year). However, heating and cooling savings associated with the VAV conversion, as well as savings from two other measures, rely on the DOE2.1E model. Except for the air-handler metering, this model uses hardly any measured data. Calibration is performed using monthly billing data, and though the discrepancies between the simulated consumption and the actual consumption average to less than 6% a year, the monthly error is often 10-24%. Part of this may be attributed to the use of TMY weather data, but there exists an equal likelihood that the model needs adjustment. If the model is improperly adjusted, the savings estimates may be inaccurate, and the NPS bears most of this risk. On the other hand, VAV conversion is a common and reliably successful ECM, and for only $7,000 in savings the extra cost of developing a more rigorous model is questionable.

The Lighting Retrofit uses the minimum amount of M&V allowed in the FEMP guidelines. For a lighting project this size, however, this is probably appropriate. The hours of operation are carefully divided into usage groups with reasonable usage estimates. The use of ANSI standard fixture wattages may inflate savings estimates somewhat, but more risk probably exists in the accuracy of the lighting audit. Quantifying this risk is difficult without more information.

The SuperESPC project at Yosemite shows the importance of FEMP/DOE support—and of M&V education in general—in mediating risk. While the FEMP guidelines contain useful M&V approaches, it was a class on the subject that most benefited the Yosemite technical representative. But understanding the importance of M&V does not reduce the cost of M&V, and it was the grant from DOE that extended the M&V beyond the bare minimum. This money was spent effectively, providing measurements for the two ECMs with the most energy savings.

2. SITE 2: VETERAN'S AFFAIRS MEDICAL CENTER, SAN FRANCISCO, CA

Site Contacts:	David Macheel, Chief Engineer, Dirk Minimah, Engineer, Veteran's Affairs Medical Center, San Francisco
Interview Date:	10/6/1999
Schiller Representatives:	Ben Gallant and Mark Stetz
Documents Reviewed:	M&V plans: Initial Final Final H-schedules

2.1. Project Motivation

Shortly after the DOE awarded Johnson Controls International (JCI) one of the SuperESPC contracts, JCI approached the Veteran's Affairs Medical Center (VAMC) in San Francisco about performing an audit. The VAMC already used JCI's proprietary Metasys controls system, so Johnson Controls was already a presence at the VA site. The VA facilities staff saw a golden opportunity to finance some much needed equipment improvements while reducing energy costs.

Johnson Controls performed a walkthrough audit to identify potential measures for the VA. JCI originally identified 13 measures that would save energy, labor costs, or both. In addition to energy-saving measures, the VA was specifically interested in reducing the labor costs associated with their steam plant, which required constant supervision, and with replacing the old and problematic medical air compressors. The VA and JCI negotiated these measures to a final of six, chosen both for their payback period and for their value to the VA as equipment upgrades. JCI was able to propose the most costly measure, substituting the existing boiler plant for a new steam generating system, because of the large associated labor savings.

The VA did not seek other offers from the other SuperESPC awardees, nor did the VA pursue other funding options. JCI presented an opportunity to install new equipment and reduce labor costs, to which the VA readily agreed.

2.2. Project Description

The six measures in the final DO include lighting, boiler replacement, controls upgrades, and efficient motors. The largest project savings come from labor cost reduction associated with the boiler plant; the second largest savings are from lighting measures.

Table 1: VAMC SuperESPC Delivery Order ECMs

Measure	Cost (total)	Energy & O&M Cost Savings	M&V Method*
Replace Boilers with New Steam Production System	$2,618k	$8,000 (O&M: $304,000)	B
Controls Upgrade & Life Safety Supervisory System	$333k	$42,000 (O&M: $2,000)	A
Replace Air Compressors	$227k	$4,000 (O&M: $9,000)	B
Replace Cooling Coil	$44k	$15,000	A
Lighting Retrofit	$926k	$121,000 (O&M $7,000)	A
Motor Efficiency Upgrade	$66k	$18,000	B
Total	**$4,429k**	**$208,000** **(O&M: $322,000, 61%)**	**Avg. Annual Cost** $25,286

*Note: M&V Method is not necessarily that claimed by JCI in the M&V plan. JCI's interpretation of the method definitions is different than the intent of the guidelines in some cases.

2.3. M&V Development Process

Most of the contract negotiation involved selecting measures that the VAMC wanted and would yield an economically feasible project, rather than discussion of M&V issues. Sixty percent of the total savings come from labor reduction and no M&V effort was expended (or necessary) to quantify this. The boiler plant required 5.2 full-time equivalent employees, so characterizing displaced labor was a trivial task.

Johnson Controls performed all of the M&V plan development, and used the FEMP guidelines at least to format the plan and to classify M&V methods, although some of these classifications are questionable. There did not appear to be too many discussions that resulted in much change to the plan. The FEMP team reviewed and agreed to the plan. The only major issue that appeared to be discussed was why and how the energy costs used to evaluate savings would be escalated at 3% per year. Even though energy savings remain constant, this results in an increase in the claimed dollar savings and allows JCI to increase their payments over the 18 year contract term, presumably in order to meet escalating labor expenses.

The VAMC appears confident that the energy savings will materialize and that the project as a whole is relatively low-risk. Lighting operating hours are reasonably well-known (but not measured) while efficient motors operate 8760 hours per year or are controlled by time-clocks.

Thus, Measurement and Verification of savings was not a primary concern of the VA for several reasons. First, the O&M savings will not require any M&V; second, the equipment upgrades will improve the hospital facilities performance regardless of energy savings; and finally, the VAMC feels that energy savings will exceed the guaranteed amounts.

2.4. Use of M&V Guidelines

Johnson Controls used a variety of methods to verify savings in their M&V plans, several of which did not clearly fit into FEMP Guidelines classifications, or exactly follow Guidelines' methods. For example, the M&V plan for the motors upgrade is identified as Option B because annual kW spot measurements are used to calculate savings. However, the method does not use any short term metering as described in the Guidelines' section on Option B motors project. The actual method is somewhere in-between.

Similarly, damper reconditioning, which falls under the controls upgrade ECM, relied on a building simulation model to estimate savings. These estimated values are to be stipulated over the contract term. Persistence is addressed by conducting regular inspections to ensure that equipment is functioning properly. JCI referred to this method as Option C because of the use of computer simulations, but we feel it more closely resembles an Option A approach because the savings values are stipulated and the simulation is not really whole building analysis.

Both of these methods are reasonably appropriate M&V approaches under the given conditions, but neither appears to draw much from the FEMP Guidelines.

The VAMC is tracking their utility bills as a secondary method of tracking savings. They had already seen a 5% decrease in electricity consumption even though the lighting measure was not yet complete at the time of our interview. Using the utility bill consumption at this site to track savings with an Option C approach probably would also provide an acceptable alternative to the combination of methods presently being used. The facility maintains a relatively constant schedule and is located in a moderate climate, making option C a viable alternative to existing methods. It does not appear that this was ever proposed. However, it can serve as a backup measure to compare to JCI's estimates from their M&V reports.

2.4.1. Boiler Replacement

This ECM accounts for 4% of energy cost savings, 46% of therm savings, and -12% of kWh savings (loss).

The boiler system was changed from a pressurized steam system to an atmospheric pressure system with a steam generator. Although the increased efficiency of the system will provide some therm savings, most of the savings are from labor reductions. Electricity usage will actually increase due to new oil circulation and heat recovery pumps.

Savings will be estimated with an Option B approach. JCI measured the efficiency of the existing boilers and found them to have an efficiency of 76%. The new system is guaranteed by the manufacturer to have and maintain an efficiency of 80%. Johnson Controls will use the EMCS to continuously monitor steam production and gas consumption to calculate energy use and boiler efficiency. Savings will be based on the ratio of boiler efficiencies. This allows continuous tracking of system performance and automatic baseline adjustment; it also adjusts for interactive savings with other measures that affect heating and cooling loads. This approach appears entirely suitable for this measure.

Because the new steam generation system can be automated, it does not require continuous human supervision. This allows the O&M savings to be estimated directly from the displaced labor of 5.2 full-time equivalent employees. The boiler operators are being retrained to fill several openings in the currently understaffed facilities crew.

2.4.2. EMCS, Controls Upgrade, & Life-Safety Supervisory System

This ECM accounts for 20% of energy cost savings, 54% of therm savings, and 7% of kWh savings.

This ECM is actually several measures rolled into one. It includes reducing the operating hours and/or the speed of three air-handler fans, and reconditioning of air handler dampers. In addition, the Life-Safety Supervisory System (fire alarms) is to be replaced. There is no energy savings associated with this last improvement, but it was important to the VA replace this system, and this measure was thus grouped with energy savings measures to make it cost effective.

The M&V approach to the air handler rescheduling and VFD is Option A. Two of the fans that currently run continuously at full power will have VFDs installed to run the fans at 80% speed during unoccupied hours. Another fan will be controlled to shut down completely during unoccupied hours. Pre-installation kW was derived from motor data and a spot RPM measurement. Post-installation kW will be spot measured annually. Operating hours will be stipulated based on the EMCS. This approach is appropriate for these measures and should yield reliable verification.

The M&V for the damper reconditioning measure uses a computer simulation to estimate electricity and natural gas savings. Savings are then stipulated based on these estimates (Option A), and the dampers are inspected on a monthly basis to ensure continued effectiveness. The M&V plan does not specify what simulation program was used, nor does it provide any details on the approach used or the assumptions made. Since estimating savings from damper operation using an Option B approach requires significant data collection and analysis, using computer simulation to estimate typical annual savings is an acceptable alternative. Real savings will fluctuate with weather conditions, but over 15 years can be reliably approximated using this method. So long as JCI continues to periodically inspect damper operation, this method is appropriate for this measure and its associated risk.

2.4.3. Air Compressors

This ECM accounts for 2% of energy cost savings, 3% of kWh savings, and 0% of therm savings.

Three existing 25 HP air compressors are being replaced by two 40 HP compressors. An engineering estimate was used to determine pre-installation energy consumption, though it is not entirely clear from the M&V plan exactly how this was done. Post-installation kWh will be measured directly through the EMCS. Most of the measure savings will come from labor reduction, but it was not clear how the O&M savings were developed.

This Option B approach uses very accurate post-installation data, but the estimated savings are less precise because the baseline consumption does not seem to be clearly defined. Savings are based on ratios of equipment performance instead of historical consumption; savings will therefore depend on both equipment performance and air consumption. This places both JCI and the VAMC at risk, but for different reasons. (JCI is at risk if consumption decreases, the VA is at risk if equipment performance degrades.) However, this measure has the smallest energy cost savings in the project, so these risks are minor.

Replacing the old and problematic air compressors was a high priority item for the VA, and the energy savings are minimal. Reducing O&M expenses and increasing reliability was a higher priority than saving energy. Engineering estimates and a single performance measurement were used to estimate the baseline performance. Given the project motivation, small energy savings, and crudely estimated baseline, the effort required to monitor post-retrofit consumption seems excessive. Savings estimates will not be any more reliable and extra expense will be required to collect and analyze the data. At $4,000 per year energy savings, an Option A approach with occasional spot measurements may have been a more appropriate method.

2.4.4. Cooling Coils

This ECM accounts for 7% of energy cost savings, 3% of kWh savings, and 0% of therm savings.

Due to the salt air at this location, some of the cooling coils were corroded and clogged, reducing air flow and significantly increasing fan energy consumption. By replacing the existing coils with new, pressure drop and fan energy were significantly reduced. A combination Option A/Option B M&V approach is being used. To estimate baseline consumption, pressure drop across the coils and fan motor demand were measured prior to replacement. These measurements were repeated with the new coils installed. Savings are then stipulated based on these measurements (the Option A part of this method) and assumed operating hours.

The EMCS will be used to monitor pressure drop across the new coils (the Option B part of this method). Changes in coil pressure drop will indicate problems and warrant attention. Fan motor demand and air flow rates will be measured annually to verify persistence. Savings are dependent on the airflow through the coil, so significant changes to air the air flow will require adjustments to the baseline and savings levels. In the absence of any air flow changes, savings will remain at the stipulated levels.

It is not clear why the new coils won't suffer the same fate as the old, but pressure drop will be monitored to detect any problems early. Tracking performance for large

40 Which would require monitoring pressure drop.

changes through the EMCS minimizes risk. Calculating savings from the collected data would not yield significantly more reliable savings estimates and the effort would not be justified. Given the large and easily quantifiable savings from this measure, the level of M&V appears appropriate.

2.4.5. Lighting

This ECM accounts for 58% of energy cost savings, 81% of kWh savings, and 0% of therm savings.

Lighting savings represent the second-largest total savings component in this project, and the largest energy savings component (excluding O&M savings). An Option A approach with measured fixture powers and stipulated hours will be used to estimate savings.

Pacific Gas & Electric provided lighting incentives through a lighting rebate program. This rebate was passed directly on to the VA in a lump sum and was not factored into any of the cost or savings estimates.

2.4.6. Motors

This ECM accounts for 9% of energy cost savings, 12% of kWh savings, and 0% of therm savings.

Johnson Controls replaced many fan and pump motors with more efficient models. Many of these motors operate continuously at nearly-constant loads. Others are controlled by time clock or the EMCS and therefore have known operating hours. An Option A/B method was implemented by taking spot-measurements of all affected motors and using stipulated hours and to calculate the savings. The new motors will be spot measured annually for kW consumption and the new kW measurements will be used to calculate savings.

Because of the long operating hours of these motors and their long life, this represents a low-risk project that should provide savings for many years. Baseline adjustment should not be necessary and the spot-measurement approach is appropriate for this measure.

2.5. Risks Associated with M&V Plans

Overall, the M&V plan will provide a reasonable estimate of the energy savings at this facility, although there will be more uncertainty associated with some measures than others. In general, more attention has been given to post-installation usage and performance than pre-installation conditions, placing the risk of an improperly defined baseline on the VA. Provisions for baseline adjustment based on post-installation system output are generally included where appropriate. The VAMC will be responsible for the operations and maintenance of all measures except the controls system. JCI will be responsible for major repairs and replacements.

One of the unusual features in this M&V plan is the energy cost escalation used to calculate the dollar amount of the savings. Johnson started with the present energy prices in 1998 and will escalate these prices by 3% per Energy Information Administration guidelines. As a result, the guaranteed savings escalate by 3% per year, which allows JCI to charge greater annual payments in later years. Escalating energy prices contradict current thinking with respect to energy prices, which are expected to decrease following the restructuring of California's utility industry. However, valuing dollar savings at actual energy costs places JCI at risk of failing to meet dollar savings goals even when energy savings goals are met. In the event of decreasing energy prices, the VAMC will pay lower energy costs regardless and is not at risk.

The total cost for M&V services are 5% of the annual payments (Net Present Value), or about $25,286 per year. For a project of this size, this payment may be a little greater than expected, especially considering that many of the measures are using an Option A approach or using data from the existing EMCS. Since the VAMC is not placing a great emphasis on verifying the savings, the added value of the M&V services is suspect.

Almost 80% of the energy cost savings are generated in two measures; lighting and controls upgrade. Yet both of these measures use Option A approaches (albeit fairly appropriate applications of Option A) while other measures like the boiler replacement and air compressors use more costly Option B approaches even though their combined energy cost savings is less than 6% of the total. The presence of the EMCS at this facility does make some Option B methods less costly, but it is important to remember that the wealth of data available from this system does not necessarily improve the energy savings estimates if baseline conditions are not properly defined. Better to spend time improving the confidence of the large-savings stipulations than crunching numbers from the EMCS for small-savings measures.

One example of where risk could perhaps been reduced without an increase in M&V cost or a change in M&V Option is lighting. Lighting projects typically are low-risk, it is often helpful to verify the operating hours through short-term metering. Many of the fixtures are stipulated to operate 9 hours per day. If sufficient number of fixtures operate less than this amount, savings will not be realized. In contrast, fixture power data is readily available from manufacturers and from reference sources, so measured fixture powers could be a source of misplaced cost and effort.

2.6. Other Comments

Measurement and Verification does not appear to have been a primary concern in the VAMC Delivery Order negotiations. Looking over the M&V plan, the engineering staff at the VAMC felt the savings calculations looked reasonable, and had faith in the FEMP team's review of the plan (The VAMC paid for the FEMP team's services, unlike some earlier projects for which the services were free.) Also, since the majority of the savings was in O&M costs, energy savings M&V took on

[MLS0]42 Amen, brother.

less importance. In the end, the DO included an M&V plan based loosely on the FEMP guidelines that should provide reasonably accurate verification of the savings at the VAMC, even if the cost of M&V is not always proportional to the savings of the measure.

3. SITE 3: FOREST SERVICE LABORATORY, CORVALLIS, OR

Site contacts:	Cathy Griffith – Contract Administrator Jerry Carlson – USFS Facilities Engineer Primo Knight– Inspector Bob Lynn - Facilities Manager
Site Visit Date:	October 8, 1999
Schiller Representatives:	Lia Webster, Mark Stetz
Materials Reviewed:	Initial proposal; Final Delivery Order; Narrative Bridge, M&V Plans

3.1. Project Motivation

The United States Forest Service Laboratory provides laboratory and office space to researchers at Oregon State University. The USFS sub-leases its facilities to researchers, who pay a share of utility costs through their rent on a per square foot basis. Because of this cost-sharing arrangement, the USFS was interested in reducing their expenses so that their facilities would be economically attractive to the researchers. Other motivations for pursuing energy conservation measures included EPACT compliance, as well as a desire for "doing the right thing."

The USFS started exploring energy-service contracts as early as 1993 with their utility provider, PacifiCorp. Initial legal advice discouraged the USFS from using PacifiCorp's energy services because of their lack of guaranteed savings. In 1997, Honeywell was selected as a SuperESPC service provider and was directed to the USFS by the DOE, who was aware of the Forest Service interest in energy services. Honeywell approached the USFS to perform an audit at the laboratory, which the USFS agreed to. By December 1997, Honeywell and the USFS collectively identified four measures that combined would save $84,000 per year in energy and O&M costs. Over the next year and half, the proposal was revised several times to make changes to the project and the M&V plan.

3.2. Project Description

The laboratory, built in the late 1960s, has five conditioned wings and two unconditioned areas totaling about 105,000 square feet. The laboratory has regular office spaces and working laboratories. Some of the laboratory space was converted to office space in the 1980s. SuperESPC project construction was scheduled to coincide with a ceiling remodeling project.

Honeywell's ultimate package of three energy-conservation measures required an initial investment of $394,000 and will save an estimated $63,000 per year in energy costs and an additional $14,000 in operations & maintenance costs. The energy savings from this project represent a 40% reduction in utility bills. Energy measures implemented include lighting upgrades, a new control system, and steam system improvements. Total project cost over the ten-year contract term is $685,000. The ten-year contract term was the longest that the USFS would accept, so Honeywell had to identify which projects would fit within that limitation.

Table 2: USFS Laboratory SuperESPC final proposal

Measure	Capital Cost	Energy Savings	Total Savings	M&V Method
Lighting	$165,000	$22,500	$27,500	A
Controls	$153,000	$22,600	$25,200	B/D
Steam System Upgrades	$76,000	$18,000	$24,500	A
Total	$394,000	$63,100	$77,200	

3.2.1. Lighting

Existing lighting was primarily fluorescent T12 four-lamp fixtures with magnetic ballasts, along with 130 W and 300 W incandescent lamps in the hallways. Honeywell retrofitted the office fixtures to T8 fluorescent lamps with tandem-wired electronic ballasts. Most of the fixtures in this facility were delamped to provide additional energy savings. Incandescent lamps were replaced with two-lamp fluorescent fixtures. This measure represents a $165,000 investment that will save $27,500 annually (36% of the savings).

3.2.2. Controls

Honeywell replaced the existing pneumatic control system with a modern direct digital control (DDC) system for better and more reliable control. This system now operates the HVAC and make-up air (MUA) units in the laboratory and provides night setback. New controls reduce the operating hours of the MUA unit by limiting operation to periods when the OSA is less than 40° F, decreasing both fan power and heating load. Chiller operation is now controlled by outside air temperature in addition to timed control (it was previously under timeclock control only.)

The Honeywell system improves the control strategy by basing operation on outside air temperatures and space temperatures. Savings are due to reduced fan and chiller operating hours and to optimized control strategies. However, the air supply system was not balanced as part of this project and the system still needs some tuning. After Honeywell completed the project, the USFS added more points to the new control system to automate control of radiator valves. This project represents a $153,000 investment that will save $25,000 annually (33% of the savings).

3.2.3. Steam System Upgrades

Honeywell replaced the bucket steam traps with orifice traps and insulated the bare steam lines. Some of the existing steam traps were leaking or failed, wasting steam and energy. Replacing them with orifice traps eliminates wasted steam and improves trap reliability. None of the existing steam lines were originally insulated, leading to considerable thermal losses. This measure will cost $76,000 and provide $24,500 in annual savings (32% of the total).

3.3. M&V Development Process

Honeywell developed M&V plans for each measure which were then reviewed by the FEMP support team (primarily Mike Holda and Steve Kromer), who reviewed and suggested changes to the M&V plan. The USFS preferred that FEMP representatives actively supported M&V plan development because they felt that M&V was outside their area of expertise. For this project, the USFS did not have to pay for FEMP support services but would have if necessary. They felt that the advice of the FEMP team would be worth the small investment.

During project development, M&V discussions centered on specific assumptions and energy costs used to estimate savings. Honeywell revised the M&V plan as a result of these discussions, but their overall approach remained constant over four proposal revisions. The reviewers did express some concern over the proposed minimum savings, but felt that the risk to the USFS was small. Measurement & verification expenses are about $6,700 per year, or about 11% of the annual energy savings.

Honeywell used Option A on projects with low risk (lighting) or on projects where estimating savings from measurements would be difficult (steam traps and pipe insulation). Option B was used on the controls measure because otherwise it would have been difficult to isolate savings from that measure. The controls system records its actions, making option B fairly easy to implement.
Honeywell claimed operations & maintenance savings for these measures to improve project economics. Savings will come from reduced lighting, controls, and steam trap maintenance and from reduced lighting and steam trap replacement costs. Savings estimates were based on parts and labor records that the USFS provided, although the USFS expresses some reservations about these values. The USFS developed these estimates cautiously, knowing that their O&M budget would be reduced accordingly.

3.4. Use of M&V Guidelines

Although the USFS had previously considered obtaining energy services from different sources (PacifiCorp, Bonneville Power Authority) under shared-savings contracts, they were not familiar with the FEMP M&V guidelines until Jerry took an FEMP training course and started negotiating with Honeywell. The USFS staff is more comfortable with guaranteed savings than shared-savings and they understand the risk of variable savings that energy service projects offer. Guaranteed savings were not necessary to sell the project to USFS staff in Corvallis, but it did make the proposal more attractive.

Implementing M&V was not a major concern to the USFS because of their understanding of project risks. Having guaranteed savings made it easier to sell the project to the researchers, who needed to agree to the project before it could p roceed. In this project, M&V will be used to show that the actual savings are meeting the guaranteed amounts.

3.4.1. Lighting

Lighting M&V is being performed with Option A using measured fixture powers (pre- and post-retrofit) with stipulated hours. Operating hours for different space types were determined from interviews with facility staff and were stipulated based on these results. The only significant change in strategy was the inclusion of baseline adjustments if additional fixtures are added or removed from an affected space, although it was not described how these baseline adjustments would be performed.

3.4.2. Controls

Honeywell added DDC controls to the HVAC system, to the laboratory MUA unit, and installed a new computerized operator interface. The new control system will produce savings from decreased use of specific air handlers, from night setback, and from reduced use of chillers and pumps. Calibrated building energy simulation (Option D) was used to estimate the baseline energy use for many of the HVAC components. Baseline operating hours of the heating system, cooling system, fans, and pumps were based on system inspection and were used as calibration model parameters. The estimated baseline energy consumption from this model will be stipulated and fixed. The control system will be used to monitor post-retrofit energy consumption of HVAC components (Option B). This combination of options (B/D) is not explicitly described in the FEMP guidelines, but can be more accurately described as option B with simulation used to develop the baseline. Persistence of savings is implicit in this approach because energy consumption will be tracked continuously.

3.4.3. Steam System

The steam system upgrade consisted of installing new steam traps and pipe insulation. Option A with stipulated values was used to estimate savings. Baseline steam loss from failed traps was estimated by assuming that bucket traps fail within five years, so 20% of the traps would be leaking at any one time. The USFS was comfortable with the 20% value, as it was representative of their experience.

System operating hours were also stipulated and appear to be conservative estimates of actual operating hours. Pipe insulation savings were estimated by calculating the heat loss from the steam system with and without insulation. No measurements of steam consumption or trap conditions were used to support these estimated and stipulated savings values.

Persistence is addressed by assuming that orifice traps will last considerably longer than the bucket traps they replaced. Honeywell does not plan inspecting for or replacing failed orifice traps; this has been left to the USFS.

3.5. Examination of Risks

3.5.1. Lighting

Option A with stipulated values was selected as the M&V method for the lighting retrofit. Honeywell used power measurements of a sample of the fixtures (both existing and retrofit) that satisfies 20% precision at 80% confidence and stipulated the operating hours based on personnel interviews. Using stipulated operating hours places all risk on the USFS if the actual operating hours are less than the stipulated values. If actual hours are greater, then the USFS simply realizes greater savings.

There was (and still is) some concern over whether the stipulated operating hours truly represent actual building operation. Not all fixtures in each space type will match the agreed-upon schedules, as some people prefer darker offices while others work late in the evenings. The USFS was worried that that these differences might affect the savings they would realize. However, their review of present utility bills show that they are presently realizing about $1,500/mo savings, much of which can be attributed to the lighting measure. This check against their utility bills has provided confidence that the lighting savings are materializing and that the stipulated values are realistic.

The USFS will maintain the fixtures by replacing tubes and ballasts as needed. So long as the USFS maintains the correct parts inventory, this measure will continue to provide savings. Honeywell has no plans to perform an annual inspection to verify that the fixtures are properly maintained. This places the persistence risk on the USFS.

O&M costs will be reduced because the new equipment should operate reliably for many years. The USFS presently has no plans to practice group relamping and will simply replace lamps as they fail.

3.5.2. Controls

Baseline energy consumption was estimated from the result of a calibrated simulation model and will be the stipulated baseline (what Honeywell calls Option D). The simulation models used TMY weather data; there is no provision for adjusting the model to account for actual weather conditions. Post-retrofit energy use of the MUA and HVAC systems will be monitored by the control system (Option B) and will be used to calculate the new energy consumption.
Honeywell proposed a minimum level of energy savings in the event that mild seasons depress actual energy consumption and savings. Actual outside temperatures will be monitored and used to calculate the heating & cooling energy consumption. In the event of a mild winter (HDD less than 4,489), then the baseline value of 4,489 HDD will be used to estimate the minimum savings. If the winter is colder than 4,489 HDD, then the actual conditions will be used. (The analogous situation applies to the cooling load of 258 CDD.) This reduces Honeywell's risk by ensuring that mild winters or summers do not depress the claimed savings below the guaranteed amounts. However, this does not necessarily increase the risk to the USFS. Mild seasons will also reduce the total heating & cooling energy consumption, so total expenditures will be less than in typical years.

Honeywell has not provided an annual M&V report to document savings. As an independent confirmation of savings, FEMP requested that the Bonneville Power Administration install data loggers on the main electric meter. This data logging system shows clearly that the control system is cycling fans and chiller, reassuring the USFS staff that the system is performing as expected. The system has not functioned through the winter yet, so heating energy savings have not materialized.

O&M savings are being claimed for this measure because DDC controls are more reliable than pneumatic and will require fewer repairs. Additional O&M savings will be realized due to reduced calls for comfort issues (i.e., room too cold). This is the only measure that Honeywell will maintain, although the USFS will operate the control system.

3.5.3. Steam System Upgrades

Two steam system upgrades are being proposed- trap replacement and pipe insulation. Both measures use an Option A approach with stipulated values. For the steam trap upgrades, assumed values used to estimate the baseline energy consumption are the blow rate of failed traps, annual operating hours, percentage of traps failed, and steam enthalpy. Documented values include trap size, orifice diameter, trap pressure, and steam capacity. An “industry-standard” assumption of 20% failure rate as the fraction of failed and leaking traps was stipulated. No attempt was made to test the existing traps before or after removal to quantify their operation, nor will Honeywell inspect the new traps after installation to verify savings persistence. Instead, Honeywell states that orifice traps are much more reliable than bucket traps.

The USFS accepted the 20% value, as it agreed with their trap failure rate and maintenance practice of replacing or rebuilding traps once every four years. Using the actual failure rate at the time of the audit also might not have provided a representative failure rate, as traps fail sporadically. If the surveyed failure rate were high, then the estimated savings might be overstated. If the surveyed failure rate were low, then the savings might be too low to make the project economically viable. Using the stipulated failure rate was a way to balance the risks with economic feasibility.

For the pipe insulation measure, all values are stipulated. Insulation savings will be estimated based on assumed heat loss values from bare insulated p ipes. No baseline adjustments will be made. Given the difficulty of directly measuring heat loss (Option B) and the difficulty of isolating piping heat loss using an Option C (billing analysis) approach, stipulating the savings based on assumed values (Option A) was really the only viable approach. There is little risk and high persistence associated with this measure.

One project risk is whether the stipulated steam system operating hours are realistic. Different operating hours were assumed for the steam trap and insulation projects, possibly because of differences in which parts of the system were thought to be energized during the year. Some of the system is energized all year for DHW and autoclave operation while other sections are enabled only during the heating season. This most likely makes the actual operating hours greater than the stipulated values and the savings estimates conservative. However, the upgrades have been in place less than a year and it is not yet apparent whether steam savings are materializing.

Honeywell is claiming O&M savings based on steam trap parts and labor costs. The USFS provided the costs of these items.

3.5.4. Energy Costs

Pacific Power & Light supplies electricity at $2.61/kW and $0.034/kWh; steam is purchased from Oregon State University at an average value of $1.07/therm (1998 rates). Honeywell anticipated future energy price changes and originally used these prices as minimum prices to value energy savings. In their first M&V plan, if energy prices were to decrease (due to rate changes or deregulation), energy savings would be valued at the 1998 prices. If energy prices increased, Honeywell would value the energy savings at the new prices. This strategy protects Honeywell from decreasing energy costs that would erode fiscal savings (they would not meet their financial savings even if energy saving goals were met). Conversely, increasing prices present a different type of risk. It would allow Honeywell to claim guaranteed fiscal savings even if energy savings goals were not met and place the USFS at risk. Since the SuperESPC savings are tied to energy- not financial- savings, it was felt that this strategy was inappropriate. In response to comments from the FEMP reviewers, Honeywell revised their M&V plan to value energy savings at fixed (1998) rates over the life of the contract. This will ensure that financial savings are tied to energy savings. This is a fair distribution of risk against changing energy prices, and protects the USFS and Honeywell equally.

3.6. Other Comments

Measurement and verification of savings was not a major issue during contract negotiations. The USFS understood the risks associated with performance contracts and was not too concerned about verifying savings for each measure. The addition of guaranteed savings places the risk back onto the contractor and improved the USFS comfort level with this project. Since the project completion in early 1999, the USFS has been paying close attention to their utility bills to validate the savings estimates, and has verified savings from the lighting and controls project. They will be monitoring their steam consumption this winter to validate their steam savings. At the DOE's request, the Bonneville Power Administration installed data recorders on the main electricity meter to monitor demand as a function of time. This information was used to verify the proper operation of the control system. These secondary M&V approaches are used because of the large amount of stipulated savings and the desire to independently verify total energy savings.

The USFS was more concerned with obtaining improved functionality with their new control system. They were willing to pay more (by extending the contract term) to obtain a system that would provide more control in order to obtain more savings. They also wanted to upgrade the quality of their lights and use full-spectrum bulbs instead of the typical cool white bulbs originally proposed. They were happy to obtain better lights, an improved control system, and steam system upgrades without requiring capital funds to do so. They were especially pleased to obtain these things in a package where they had some input and control in the final proposal. The researchers also benefit from reduced energy costs that are part of their overhead expenses.

4. SITE 4: FEDERAL AVIATION ADMINISTRATION — AUBURN, WA

Site contact:	Shirley Cochran – Contracting Officer Bob McGranahan – Facility Manager
Site Visit Date:	September 1, 1999
Schiller Representatives:	Lia Webster, Mark Stetz
Materials Reviewed:	Initial proposal; Final Delivery Order; Narrative Bridge

4.1. Project Motivation

An initial request for proposal (RFP) was released in June 1997 by FEMP for the Western Region SuperESPC. The RFP included requests for proposals for several project sites, including the FAA's ARTCC[2]. The FAA site was invited by FEMP to take part in this solicitation as part of the initial SuperESPC projects. The FAA had previously expressed an interest in complying with EPACT mandates and reducing energy costs. The SuperESPC program was the only mechanism available to the FAA to comply with the EPACT mandate. The FAA was also interested in realizing some energy cost savings.

Five proposals from separate organizations were selected for these sites by the FEMP team, who became the five approved SuperESPC service providers for the Western Region. In order for these initial SuperESPC projects to be implemented in a timely fashion, a separate provider was chosen for each site. The FAA reportedly had second pick, and selected Johnson Controls based on their proposal. The Delivery Order (DO) for this project was signed in July 1998, and was the first one issued in the Western Region under the SuperESPC program.

4.2. Project Description

The Federal Aviation Administration's (FAA) Air Route Traffic Control Center (ARTCC) in Auburn, Washington was originally built in 1962, and has approximately 185,000 square feet of occupied space. This facility houses an air traffic control center serving the western United States and the proper operation of the facility systems is critical for the operation of the FAA computer systems. The majority of the facility operates continuously, while other areas are occupied only during normal business hours

Johnson Controls was limited to a brief walk-through of the FAA facility prior to submitting their original proposal. The original proposal included recommendations for: lighting retrofits; lighting controls; energy efficient motor replacements; installation of variable frequency drives for fans, pumps and chillers; air system reconfiguration; and automated control system expansion. Once Johnson Controls was selected, a detailed site energy study, feasibility study, and cost analysis were

2 FAA ARTCC 3101 Auburn Way So., Auburn, WA 98022

conducted. The final implemented ECMs included comprehensive lighting retrofit, occupancy sensors for office lighting, and variable frequency drives for central plant pumping.

Table 3: SuperESPC Project Statistics: ARTCC FAA — Auburn, WA

Measure	Capital Cost	Annual Energy and O&M Cost Savings	M&V Method
Lighting	$100,728	$18,056	LE-A-02
Variable Frequency Drives	$203,221	$32,215	VSD-B-01
Detailed Energy Study	$28,361	$0	-
Total:	$332,310	$50,271	-

The electric bills for the FAA ARTCC facility were approximately $480,000 in 1996. Predicted annual cost savings represent a cost reduction of approximately 10%.

4.2.1. Lighting Retrofit and Controls

Johnson Controls performed a comprehensive lighting retrofit of the FAA ARTCC facility. The primary retrofit involved replacing fluorescent T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts. Additionally, LED exit signs were installed, dimming fluorescent systems were replaced with standard light switches and electronic ballasts, incandescent lamps were replaced with compact fluorescent lamps, and some fixtures were replaced with new higher efficiency ones. Occupancy sensors were installed in some private offices and conference rooms for control of lights in those areas.

During the detailed site study, it was found that the lighting retrofit requirements were substantially different than originally indicated in the site data package.

The M&V option used for these lighting measures was stated in the DO to be a combination of LE-A-01 and LE-A-02, although it is actually an incomplete application of LE-A-02. The baseline energy use of the lighting fixtures, based on the detailed site survey conducted by JCI, was determined from a standardized table of fixture wattages. Nineteen usage groups were assigned based on the post-retrofit fixture characteristics. The steady-state energy use of selected sample fixtures within these groups was measured after installation, and the operating wattages will be verified annually. The baseline and measured fixture wattages are then used with the stipulated operating hours to determine energy savings. The reduction in operating hours of the fixtures using occupancy sensors is also stipulated.

4.2.2. Variable Frequency Drives for Central Plant Pumping

The central plant for the FAA ARTCC facility consists of three chillers, each with a dedicated 50 HP chilled water pump. Prior to the project, manual reducing valves were used to throttle the pumps to achieve the desired chilled water flow from these pumps. Variable speed drives were installed on each of these three pumps through the SuperESPC project. The desired flow rates are now achieved through reducing the pump speed, allowing manual controls valves to remain open.

The condenser water system for the three chillers is pumped by one of three 75 HP pumps. Manual reducing valves were used to achieve the desired chilled water flow from these pumps. A single variable frequency drive was installed to serve any one of these three pumps, which alternate operation. The desired flow rates are now achieved through reducing the pump speed, allowing manual controls valves to remain open. Control points for the new variable frequency drives were added to the existing Metasys digital control system.

4.3. Use of M&V Guidelines

The contract administrator on this project attended a SuperESPC training session. Because this project was one of the first implemented, the FEMP M&V Guidelines had not yet been published when this project began. The FAA staff did receive a copy of the Guidelines later in the Delivery Order process.

4.3.1. Lighting Retrofit and Controls

The operating hours for the lighting systems were developed with the help of the FAA and are stipulated in the contract. The energy savings are determined by comparing measurements of post-retrofit fixture wattages with wattages from standardized tables based on the pre-retrofit audit data collected by the contractor. Operating hours are stipulated.

Occupancy sensors were installed in approximately 50 areas, primarily private offices and conference rooms. The baseline operating hours as well as the reduced operating hours from use of the sensors are stipulated.

4.3.2. Variable Frequency Drives for Central Plant Pumping

Due to the critical nature of the FAA facility, the central chiller plant is operated at all times. Full equipment redundancy is present for all systems. The baseline operating conditions for the chilled and condenser water pumps were set at 8,760 hours, with 600 hours for a second chilled water pump. The FAA facilities staff carefully reviewed and agreed to these conditions. The equipment operating hours are based on historic chiller logs.

The M&V option specified for these variable-speed pumping measures is method VSD-B-01, and this installation closely follows the Guidelines. For this system, a constant operating baseline was used for the pumps since both the condenser and chilled water pumps are know to operate primarily in a single steady-state mode, with 2 chilled water pumps occasionally having simultaneous operation. The baseline conditions are based on short-term power measurements of the pumps. Since the installation of the VFDs, the actual operating time and speed of these pumps is being constantly monitored by the control system, and average daily speed is recorded.

During system commissioning, the speeds of the pumps were correlated to energy consumption. This correlation is used to determine post-retrofit pump energy use. The minimum operating hours were stipulated. One condenser water pump and one chilled water pump have a minimum run time of 8,760 hours per year, and a second chilled water pump has a minimum run time of 600 hours per year. It is not clear how adjustments will be made if predicted savings are not realized.

The correlation between the speed of the pumps and the energy used has not yet been verified by FAA staff. Because Johnson Controls developed the correlation and is logging the data, the FAA staff feels that it would be appropriate to check these values, which they plan to do in the near future.

4.4. M&V Development Process

Johnson Controls submitted an initial proposal that outlined M&V goals and the process that would be used to develop appropriate M&V methods for the FAA project once they were selected for the job. The specific methods from the FEMP M&V Guidelines that would likely be used were referenced for each ECM. The method originally stated for the pumping VFDs was VSD-A-01, which was changed to VFD-B-01 in the delivery order. The lighting methodology did not change.

Although some FAA staff attended a FEMP SuperESPC training session, the FAA primarily relied upon the FEMP staff to advise them on matters regarding monitoring and verification for the project. The monitoring and verification plans were one of the last items negotiated in the Delivery Order with JCI. Steve Kromer and Cheri Sayer of FEMP were relied on to provide guidance on all aspects of the monitoring and verification plan. The FAA staff worked with JCI to determine occupancy hours of various parts of the facility.

After JCI was selected and had conducted a detailed energy study, a comprehensive package of measures was presented to the FAA. On October 15, 1997. After discussion with facility staff, a new refined proposal was submitted on December 23, 1997. Because there were several proposals submitted, there was some confusion among FAA staff regarding which measures were recommended and what the correct pricing was.

4.5. Examination of Risks Associated with M&V Plans

The delivery order makes provision for annual adjustment of the operating baseline for the project if required due to significant physical or operational changes made to the facility. It is not clear, however, how adjustments will be made if predicted savings are not realized from the individual measures.

The FAA anticipates converting the refrigerant in existing chillers from R11 to R134 and possibly making some other changes to the chiller plant. It is anticipated that the operating baseline will be revised at that time to reflect the new chiller plant configuration.

4.5.1. Lighting Retrofit and Controls

The FAA effectively accepted most of the risk for the lighting project. The operating hours for the facility were stipulated in the FAA's contract with Johnson Controls, and are assumed constant before and after the lighting retrofit. The FAA staff understands the risk associated with this arrangement, and carefully reviewed all operating hours assigned. Due to the constant occupancy in portions of this facility, stipulating the hours in these areas presents little risk. Stipulated values for operating hours in areas with variable hours of occupancy and/or occupancy sensors present more risk because hours of occupancy and the performance of the occupancy sensors were estimated. The lighting controls measure only accounts for only a portion of the lighting savings.

The risk incurred by the FAA will be minimal if:

- The operating hours were defined accurately and do not change over the 15 year contract; and
- The audit data accurately describes the pre-retrofit lighting system.

Although wattages of the post-retrofit lighting systems were measured, these wattages are well known and do not vary. The inventory of previously installed lighting equipment has a much greater potential for variation and therefore impact on actual savings.

Again, the FAA maintains the risk associated with the performance of the occupancy sensors. Because of the relatively small percentage of savings attributed to this measure and the extensive documentation on the performance of occupancy sensors, stipulated performance is appropriate.

Johnson Controls attributes no O&M savings to this measure. The FAA is responsible for maintenance of the lighting systems after the first year they are installed.

4.5.2. Variable Frequency Drives for Central Plant Pumping

Johnson Controls and the FAA effectively share the risk associated with this measure. The baseline operating hours and operating conditions for the pumps were stipulated in the contract. The performance of the new pumping configuration will be constantly monitored. With this arrangement, the FAA holds the risk if the hours of operation of the central plant change, or were not defined properly. Johnson Control is responsible for the performance of the new pumping configuration.

The control system is tracking the operating speeds of the VFDs and recording an average daily value. Using the average daily speed will give a much less accurate measurement of energy use than hourly measurements would since power use does not vary linearly with speed. The Metasys control system has sufficient capability to accumulate more accurate data.

Johnson Controls attributes no O&M savings to this measure. Johnson Controls is responsible for the repair or replacement of the VFDs for the duration of the contract term.

4.6. Other Comments

The delivery order and contracting process took about eighteen months. During this time, there was staff turnover at the FAA, which hindered the contract development process. Disagreements about how to proceed arose among agency staff due to a lack of understanding about the SuperESPC program. Only the contracting officer from this facility attended a FEMP training session. Additional training materials to provide to the involved parties may have been helpful.

The original Johnson Controls proposal to the FAA was for a 25-year contract. Some staff at the FAA was uncomfortable with the extended term of the contract. Eventually, the project settled on a fifteen-year contract. The primary negotiation areas centered on pricing, term, and which ECMs to implement.

The agency staff did not have a clear understanding of the value of money over time. Delivery order amounts are presented as the sum of all payment over the length of the contract term, which inflates the perception of the size of the investment. Training materials explaining net present worth or life cycle costs would be helpful.

Similarly, so many people from the FAA were involved in the decision making process, the progression was hindered by different people repeatedly asking the same questions. The staff recommended having some literature available about performance contracting that might help involved parties who have not attended the FEMP training to have a basic understanding of performance contracting

One significant side effect of the SuperESPC process for the FAA was budgeting impacts. Budgeting had to account for the payments made to Johnson Controls and a future reduction in their operating budget once the DO is completed. This requirement of sharing 50% of all saving with the general fund was unknown by the FAA staff prior to implementation, but would have somewhat reduced their incentive to achieve energy savings.

5. SITE 5: DEFENSE MANPOWER DATA CENTER — MONTEREY, CA

Site Contact:	Deneen Seril, Contracting Officer Representative
Site Visit Date:	10/14/99
Schiller Representatives:	Lia Webster and David Jump
Sempra Energy Services Representatives:	Rick Ellis, Jim Reese, and Robert Demyanovich
Documents Reviewed:	Initially proposed and final Delivery Order, M&V plans (dated April 12, 1999), final H-schedules, final Implementation Plan.

5.1. Project Motivation

The Department of Defense Manpower Data Center (DMDC) in Monterey Bay originally operated as a military hospital. When DMDC moved in, the facility systems were not updated for the new occupancy, which was primarily for office use. The major building systems operate continuously and are extremely energy intensive, using 100% outside air as well as HEPA filters in some areas. Generally, hospitals are twice as energy-intensive as office spaces. Consequently, there are many opportunities for energy savings at this facility.

At its previous location, DMDC did not have dedicated facility personnel but relied on facility engineering services from the Navy. Once in the new site, it became obvious to the staff that facility upgrades were required and that dedicated facilities personnel would be needed. DMDC has since hired a full-time facility engineer (DMDC had begun the DO process prior to hiring the facility engineer). In addition, major renovations are scheduled to begin in 2000 by MilCon[3], and will be completed after two years of construction.

DMDC had several options available for upgrading its facilities:

- Blanket Purchase Agreements (BPAs) are generally smaller in scope;
- IDIQs – 5 year terms in general, extensive process required;
- Job Order Contract (JOC) – work is performed by the Army Corps of Engineers. This mechanism just does the exact work requested, and requires a detailed scope. These projects are generally smaller in scope;
- Congressionally–appropriated military construction projects (MilCon) – hard to get, requires an act of Congress. DMDC is proceeding with such a project, as noted; and
- FEMP SuperESPC.

The FEMP option offered several advantages over the others, which included:

- Avoided going through IDIQ process since DOE had already completed it;

[3] This project is using funds allotted by congress for this facility.

- A site data package was developed for this site from a Save Energy Audit, which was funded by DOE and performed by ETC Group;
- FEMP provided pre-selected contractors, RFP, and contract;
- Financing through savings available; and
- FEMP process provided flexibility, although contracting procedures must be followed.

It was noted that for the other options, staff from DMDC would be required to be actively involved in describing what was needed, developing the projects, and writing the RFPs, etcetera. As previously noted, DMDC did not have facility staff to lead the process, although they had some idea of what projects should be implemented from the Save Energy Audit.

Other motivations for entering into the SuperESPC process included:

- DMDC management desire to use energy efficiently and to be responsible toward the environment,
- The building is owned by the Army and needed to be preserved,
- Savings (O&M funds) could be redirected to other uses after contract term. DMDC reported that they had no concerns about redirecting funds for other uses after savings were demonstrated.

5.2. Project Description

The facility was originally a military hospital on Ft. Ord Army base. The base was decommissioned in 1995 and DMDC took possession in 1996. The facility is a 25 year-old, 8-floor building totaling 367,000 ft^2. The DMDC moved in without major reconstruction, or changes to lighting and HVAC equipment.

There are three organizations resident in the building, accounting for approximately 600 people. A military construction (MilCon) project is planned to take place 2 years after the completion of the SuperESPC project, and will increase building occupancy to 1300 people.

The Army Corps of Engineers, responsible for the upcoming MilCon project, participated in the review of the SuperESPC project to ensure the compatibility of the projects. Some of the measures planned for the SuperESPC project, such as the installation of a new chiller, were shifted to the MilCon project.

The final measures included in the SuperESPC project were: boiler plant upgrade; energy management and control system (EMCS) installation; conversion to variable air volume (VAV) from constant volume, dual duct ventilation system; lighting system upgrades; hot water distribution improvements; and premium efficiency motor installation.

Total implementation costs shown in Table 4 are $2,142,880, which includes a contractor margin of 18%. Anticipated receipt of a $251,752 incentive from PG&E

through its standard performance contract (SPC) program[4], will reduce the financed amount to $1,891,128. The sum of all payments, including 8.1% financing over the nine-year contract period is $3,155,104.

Table 4: SuperESPC Project Statistics: DMDC — Monterey, California

Measure	Capital Cost	Annual Energy And O&M Cost Savings	M&V Method
Boiler Plant	$685,290	$96,846 (O&M: $53,240)	C (therms) & B (kW, kWh)
EMCS	$535,515	$166,447	B
VAV Conversion	$511,638	$86,095	B
Lighting	$161,119	$15,984	A
Hot Water Distribution	$188,554	$2,861	A
Premium Efficiency Motors	$60,764	$1,678	A
Totals:	$2,142,880	$369,911	

5.2.1. Boiler Plant Upgrade

The boiler plant upgrades involved replacing existing steam boilers and associated heat exchange equipment with two new hot water boilers. The combustion air fans will be replaced with smaller units, and the feed-water pump removed. In addition, two new domestic hot water heaters will be installed.

The upgrades to the boiler plant accounted for over 25% of the estimated project savings, half of which are from O&M savings.

5.2.2. Energy Management and Control System (EMCS) Installation

This measure will install a new direct digital control ECMS to control the operation of major building systems. The EMCS will reduce energy use by turning off equipment when not needed, as well as optimizing equipment performance. Equipment to be controlled includes the chiller, air handlers, exhaust/return fans, pumps (chilled water and condenser water), and boilers. Additional savings will be achieved through control of hot and chilled water flow to the air-handlers, set-back of AHUs, control of VAV mixing boxes, hot water temperature reset, and chilled water temperature reset. In addition, pneumatic actuators will be replaced with electronic ones. Altogether, over 800 control points will be installed.

The installation of the EMCS was estimated to achieve 45% of the overall savings. No O&M savings were included for this measure.

[4] Pacific Gas & Electric (PG&E) offers Standard Performance Contracts (SPC) to their customers to help finance energy projects.

5.2.3. Conversion to Variable Air Volume (VAV) From Constant Volume System

This measure involved selected air handlers and exhaust fans to be converted from constant volume to variable volume operation. Variable frequency drives will be installed on some air handlers and exhaust fans so they may operate at reduced capacity. Existing mixing boxes will be converted to VAV operation, and unneeded HEPA filters will be removed. Ventilation and conditioning of air to unoccupied spaces will be discontinued.

Savings will be achieved through reduced electrical use of supply and exhaust fans, as well as through reduced outside air loads. Some additional savings will be realized for the first two years of the project by reducing HVAC demands in the MilCon renovation area.

The conversion of the ventilation systems was estimated to achieve more than 20% of the overall savings. No O&M savings were included for this measure.

5.2.4. Lighting System Upgrades

The lighting system upgrade involved replacing older, inefficient florescent and incandescent lighting equipment with new, more efficient equipment. The primary retrofits were conversions from fluorescent T12 lighting systems to T8 systems. Additionally, some incandescent and HID lighting will also be replaced.

Upgrading the lighting systems accounts for less than 5% of the estimated overall savings. No O&M savings were included for this measure.

5.2.5. Hot Water Distribution Improvements

This measure involved reconfiguration of the heating hot water system to a primary/secondary piping system. New primary and secondary hot water pumps, with VFDs on the secondary pumps, will be installed. Some hot water valves on the air handlers will be changed from three-way to two-way to accommodate the new VFDs and a new expansion tank for the boilers will be installed. The domestic hot water system pumps will also be replaced.

The improvements in the hot water systems were estimated to be less than 1% of the overall savings. No O&M savings were included for this measure.

5.2.6. Premium Efficiency Motor Installation

The replacement of existing motors with premium efficiency motors will realize less than 1% of the estimated overall savings. No O&M savings were included for this measure.

5.3. M&V Development Process

The site data package for DMDC was completed in March 1998. DMDC released the Delivery Order RFP in July 1998, and received first responses from two firms in

August. A total of four firms visited the site for walk-throughs, and Sempra Energy Solutions won the bid. M&V was not as important in the selection and negotiation process as was the total savings for the life of the contract, as described in Table H-3 in the DO. Once selected, Sempra performed a detailed energy audit in December. Final proposals and negotiations continued until the DO was finalized and signed on July 2 1999. The project should be installed by the end of March 2000, and commissioned by April 2000.

DMDC had no engineering staff to assist them in their negotiations of M&V. They relied heavily on DOE staff and the Corps of Engineers. Deneen Seril, the DMDC SuperESPC Contracting Officer Representative [5], and other DMDC management staff attended FEMP training courses, and were familiar with the FEMP M&V Guidelines prior to issuing the RFP. Staff often referred to the Guidelines, and their understanding increased during DO M&V negotiations.

M&V discussions were the last big element of the DO that was addressed. Intensive discussions on M&V lasted approximately one month, with conference calls including DMDC staff, DOE staff (Cheri Sayer, Mike Holda, Steve Kromer), and Sempra Representatives. Deneen Seril said that DMDC gladly paid for the FEMP team's support. DMDC upper management stringently reviewed the cost of the M&V, and negotiated the M&V costs down somewhat. This had an impact on the level of M&V activity planned for each ECM. Table 5 shows the M&V methods planned for each ECM for the initial proposal, and the final plan. Initially, more involved M&V was planned for the project, including DOE2 computer simulation of four ECMs, and long term monitoring (Option B) the boiler auxiliary and hot water distribution motors. The final M&V plan included no computer simulation, and reduced the level of measurement for the boiler and distribution motors to support stipulation of the performance factors and operating hours.

Table 5. Comparison of initial and final M&V plans, by ECM

ECM	Description	Initial Proposal M&V Option	Final Proposal M&V Option
1	Boiler plant, boiler efficiency Boiler Plant, reduced auxiliary power	D* B	C** A
2	Energy management control system	B, D	B
3	VAV conversion	B, D	B
4	Lighting	A, D	A
5	Hot water distribution	B	A
6	High-efficiency motors	A	A, B

*Note: M&V Option D is the NEMVP option for calibrated computer simulation. The FEMP Guidelines include calibrated computer simulation and whole-building billing analysis together in Option C.
**Whole-building billing analysis is the intended Option C method.

[5] Deneen Seril, Defense Manpower Data Center DoD Center Monterey Bay, 400 Gigling Rd. Seaside CA 93955-6771

M&V costs were developed on estimated labor and materials costs associated with M&V, and are approximately 5.2% of savings, adding up to $152,931 over the life of the contract.

The initial proposal from Sempra was for a fifteen-year contract. The final DO is for nine years, after major changes in requirements since the RFP. DMDC's desire for a shorter-term contract was also influential.

Major M&V concerns discussed included:

- Understanding what M&V was all about;
- How to improve M&V and reduce the costs;
- Determining how to handle the impacts of the MilCon project; and
- How to handle interactive ECM savings.

DMDC staff perceived the risks of this project to be:

- Ensuring that they had O&M money to pay for savings;
- Verifying actual savings – DMDC will compare bills before and after project; and
- Evaluating impacts of the MilCon on the SuperESPC project.

Sempra indicated they perceived only one real risk, which was how well DMDC would maintain the equipment. Their solution was periodic inspections to see that the equipment was well maintained. Sempra also planed to remotely interrogate the new control system to periodically check system operations.

Other discussions on risk centered on properly determining the interactive savings between the ECMs — adjusting the baseline used in each calculation so that saving are not double counted. For example, the impact of boiler and ventilation changes – boiler will be used less after 100% OA ventilation is reduced – what are savings for each? DMDC relied on DOE support (Steve Kromer) to review savings calculations.

Sempra intends to be able to remotely monitor EMCS data, which helps to minimize M&V labor costs.

5.4. Use of M&V Guidelines

The baseline for this project is based on the operation of the facility systems 24 hours per day, 365 days per year using the equipment installed when DMDC took over the building.

The MilCon project affects the M&V plans for the SuperESPC project. Because the loads from the expansion in occupancy in two years are difficult to anticipate, Sempra and DMDC agreed to verify savings for only the first two years of the project, and to use the calculated savings for the remaining seven years, subject to annual checks on the equipment performance. Contractor payments are set for the duration of the contract unless energy savings are not realized in the first two years. There are no written procedures in the M&V plan which specify how savings shortfall will be addressed, should they occur.

An incentive from PG&E' SPC was anticipated for this project. The SPC program requires some monitoring during the post-installation period for each ECM. It is unclear if the anticipated monitoring results will be used to support the Option A stipulations of this project.

5.4.1. Boiler Upgrade

Natural gas and electricity savings in the boiler will be determined under two separate M&V plans. Option C – utility bill analysis– will be used to quantify gas savings by comparing utility bills. The baseline for the boiler will be adjusted to correspond to actual measured outside air temperatures. Option B will be used to quantify the electric savings from the reduced use of the pumps and fans – the baseline hours are stipulated and post-installation run hours will be measured by the EMCS, with supporting pre- and post- implementation kW spot-measurements used.

Since the boilers account for almost all of the natural gas use, the gas bills from 1997 and 1998 were analyzed to determine the baseline-heating load. This baseline load was correlated to outside air temperature so that it can be corrected for actual weather. Outside-air temperature will be measured, and this baseline will be corrected for actual daily minimum temperature. The corrected baseline will then be compared to the actual gas consumption by the new boilers to determine natural gas savings. This M&V procedure will be followed for the first two years of the contract.

The performance of the old and new auxiliary boiler equipment (fans and pumps) will be measured. The annual baseline operating hours are stipulated at 8,760 and the actual operating hours of the new equipment will be measured using the EMCS. This M&V method would be categorized as an Option B, although Sempra referred to it as Option A. This M&V procedure will be followed for the first two years of the contract.

After the first two years, these M&V verification methods effectively become Option A. The annual energy savings are stipulated for the remaining 7 years of the contract. The ESCO will perform annual measurements to ensure there has been no degradation of the equipment. The following annual activities are to be performed by Sempra:

- Measurement of boiler efficiency
- Inspection of proper boiler operations, including: flame characteristics, boiler air side conditions, boiler water side conditions, control of water temperature, firing modulation, boiler staging, power draw by boiler fans and pumps.

This measure accounts for 3% of kWh savings, 26% of therm savings, and 100% of O&M savings. O&M savings are claimed for this measure for reduced annual maintenance requirements and chemical use.

5.4.2. EMCS Installation

The savings achieved by the EMCS system will be calculated for the first two years of the project using M&V Method B, continuous metering of operating hours and performance. The savings calculations will be based on actual run time of the equipment along with spot or continuously measured performance. Some of the savings for this measure is accounted for in other ECMs, and Sempra states savings are not double counted.

After the two year M&V analysis is complete, Sempra will inspect the equipment annually to ensure proper operation, schedules and setpoints. This will include checking on/off scheduling of equipment, as well as proper control of boilers, air handlers, VAV boxes, chiller, and pumps. The M&V plan states that if changes are needed, they will be recommended to facility personnel at that time. It appears that no payment adjustments will be made in the event that sub-par equipment performance is found.

This measure accounts for 46% of kWh savings and 68% of therm savings.

5.4.3. CAV to VAV Dual-Duct Conversion

The M&V method applied to this measure is Option B, continuous measurement of run times and variable loads, along with spot measurement of constant loads for the first two years of the project.

The baseline energy use for this measure is calculated from spot measurements of power use of the existing fans with 8,760 operating hours per year. The energy savings will be determined by comparing the baseline with measured operating hours and post-installation performance measurements. Performance measurements will be continuous for variable loads and one-time for constant loads. Operating hours and continuous power measurements will be recorded by the EMCS system.

After the second operating year, the M&V efforts will be reduced to annual inspections. During annual inspections, Sempra will verify that the fans are being properly controlled by the VFDs and the EMCS, and they will take spot measurements of fan power.

This measure contributes 39% of kWh savings and 5.5% of therm savings.

5.4.4. Lighting Upgrade

The M&V method used with the lighting measure is Option A, stipulated hours determined from spot measured run times used with stipulated equipment performance. It is unclear if participation in the PG&E program affected the M&V plan for this measure.

The performance of the new and existing lighting equipment was determined from manufacturer's data based on the detailed energy audit performed by Sempra. Operating hours were measured for a sample of fixtures over a two-week period. Operating hours were stipulated from discussions with DMDC staff along with the measured run hours.

Sempra is supposed to verify lighting operating hours during their annual site inspection.

This measure contributes 9.5% of total kWh savings and 59% of kW savings.

5.4.5. Improve Hot Water Distribution System

The M&V method applied to this measure is Option A, stipulated values based on spot measurements.

The energy savings from this measure are achieved through reduced pumping power on the hot water system through use of VFDs and a primary/secondary piping system. Because the savings for this measure are so small, it was not cost effective to continuously monitor the operation of the pumps. The pumping loads are stipulated, and spot performance measurements made across the range of loads are applied. The baseline for this measure was determined from spot performance measurements of the original system configuration applied for stipulated hours.

This measure contributes 1% of kWh savings, but increases system demand.

5.4.6. Motor Efficiency Upgrade

M&V Option A and Option B are applied to this measure. Spot measurements of performance will be used before and after for motors with constant loads. Smaller motors will use stipulated operating hours, while the larger motors run times will be recorded by the EMCS. The performance of variably loaded motors is continuously measured.

The savings from this measure are predicted to be less than 1% of kWh savings.

5.4.7. Summary

In general the M&V plans for each ECM are well described. The calculation methodology is described, although the actual equations are not included (though they may be included in other sections of the DO). The variables to be used to determine the baseline and post-installation energy use are identified, as are the source of data and measurement method to quantify them. A few FEMP-Guideline recommended items are missing, however. These include a description of the sensors used, their accuracy and calibration intervals, reporting formats, and specific steps for Sempra to take in the event of a savings shortfall.

5.5. Examination of Risks Associated with M&V Plans

A project’s risk is associated with the uncertainty of the savings. M&V is used to reduce those risks, while keeping costs reasonable. Several factors influence the risk in a project: energy costs, performance of new equipment, usage of new equipment, proper definition of the baseline, appropriateness of the methodology to determine savings, and uncertainty of variables used to define the baseline and post-installation energy use and demand.

Energy costs were based on current utility rates, and no inflation was applied for the term of the contract. Non-energy elements in Annual Cost Savings and Contractor Payments, however, apply an inflation rate of 3.0%.

Actual M&V will be conducted for only 2 years after project is implemented. The MilCon project would diminish savings due to increased occupancy. After 2 years, only annual walk-throughs and performance verifications will be made (see use of M&V). Because the building use will change during and after the construction period, there will be no way to quantify the savings using the techniques proposed for the first two years. However, quantifying savings in the first two years based on measured data should provide enough confidence to stipulate the savings for the remaining years. The stipulated savings will be subject to verification of continued equipment performance. This also will cut M&V expense.

The top cost savings measures are the boiler plant, the EMCS and the VAV conversion. Total annual cost savings for these measures is $349,388, of which O&M and other savings account for only 15%. The M&V plans for these three measures have most of the necessary elements recommended by the FEMP Guidelines. In general, the calculation methodology is defined (although the actual equations are not present), the variables to be quantified are identified, as are the sources of data, and the data collection method is described.

Importantly, variables which are the most uncertain to quantify tend to be the subject of measurements in the post-installation period. Table 6 shows for each ECM the variables that will be measured.

Table 6. Measured variables for top three ECMs.

ECM	Baseline	Post-Installation
Boiler Efficiency Boiler Auxiliary Eqp.	Gas use (utility bills) Motor kW	Gas use, Op. hours, $T_{air,out}$ Motor kW, Op. hrs.
EMCS		Motor kW, Op. hrs.
VAV Conversion	Motor kW (const. load)	Motor kW, Op. Hrs. by scenario

In the baseline period, the operation hours for most equipment are stipulated, but the stipulated values are supported by good knowledge of the equipment's operation, such as an exhaust fan running 8,760 hours per year, or with measurements, such as a particular constant load motor's power draw. The M&V plan for the boiler includes an outside temperature adjustment for the baseline use to account for the effects of warm or cold years.

A potential source of risk may exist in the determination of savings after the MilCon project is implemented. Where savings from these three ECMs will have been quantified by Option B and C methods, after the MilCon project is started, they will revert to Option A methods. The contractor will continue to verify the performance of the ECMs, and use data collected on performance and efficiency, the methodology to determine the actual savings have not been pre-defined. However, the contractor has demonstrated competence in its understanding and proposed implementation of

M&V, and the agency has grounds for confidence that future M&V issues will be resolved appropriately.

5.6. Other Comments

DMDC and Sempra offered some suggestions to improve M&V negotiation process. Both indicated that the M&V discussions were long and intensive, and desired to cut down this time in favor of getting the projects started. Generally, they wanted a more streamlined process, but did not have specific recommendations. They felt the issues had to be reviewed and appropriate decisions made.

One Sempra engineer[6] indicated that M&V is viewed as a separate part of the project, and is handled separately. He recommended that it be made an integral part of the project, e.g. if one is doing a boiler, then the M&V requirements should be part of the specifications for the boiler design. This will lower costs of M&V and make them part of the overall project costs (boiler costs for example).

One comment specifically related to the Guidelines indicated that the general charts (such as Table 3.1 which summarizes Options A, B, and C) were particularly helpful. It should be made clear that options should be selected based on individual ECMs. It is important for reader to understand that each ECM option can be selected separately. Staff also noted that making specific guidelines for each kind of ECM would be difficult, but more clarity of recommendations would be helpful. It was also noted that the FEMP workshops helped quite a bit.

[6] James Reese, Sempra Energy Solutions 3100 Bristol St. Suite 100, Costa Mesa, CA 92626-3104

6. SITE 6: COAST GUARD ALAMEDA

Site Contact:	Lt. Dennis Evans Facilities Design and Construction Center Pacific (FDCCPAC) US Coast Guard
Teleconference Date:	10/13/99
Schiller Representatives:	Ben Gallant and David Jump
Documents Reviewed:	M&V plans: Initial (10/98) Final (2/99), Final H-schedules, Final O&M plan, US CG "Lessons Learned" Paper 9/20/99.

6.1. Project Motivation

The Coast Guard (CG) had been considering entering an ESPC for six years. Their motivations were to reduce energy use 20% by 2005 from the 1995 level. CG Academy in Connecticut had been trying to enter an ESPC since 1992 (when they were called Shared Energy Savings). Coast Guard decision-maker perceptions were the chief barriers to using ESPCs during this time. A number of rulemakings and changes in the Federal Acquisition Regulations removed many of the real and perceived barriers. The Coast Guard instituted an energy program. The program was centered at U. S. Coast Guard Headquarters in Washington D. C. The lead office for the East Coast energy program was Maintenance and Logistics Command Atlantic (MLCA) in Norfolk, VA. On the West Coast, the energy program was centered at Facilities Design and Construction Center Pacific in Seattle. In 1996, the DOE program manager visited CG facilities energy program to explain the SuperESPC concept, and the energy manager volunteered pilot sites at various CG sites. The first ESPC was at Academy, using the Army IDIQ. Thereafter Kodiak and Alameda projects were developed under the SuperESPC IDIQ.

Shortly after the IDIQs were awarded for the western region, the Coast Guard began developing the RFP for Alameda. Initially, CG wanted one ESCO, and a single ESPC, for its 18 largest sites on the West Coast. Motivations for projects differed; while CG station personnel had need for new equipment, the energy management team wanted to test ESPCs at their facilities. In the end, because of internal accounting procedures, more than one ESPC would be necessary. FDCCPAC focussed on getting this project started.

The energy management team at FDCCPAC wanted to pursue SuperESPC projects saw advantages to their use:

- an opportunity for acquiring new equipment with little up-front funding,
- the contractor would take on the performance risk of the project, which allowed consideration of more risky projects than the agency would normally consider,

- agency costs for annual payments would not exceed what the agency would have otherwise paid, making ESPCs “budget neutral”

Constraints in using ESPCs were:

- there must be enough financial opportunity for an ESCO to justify its investment
- sufficient savings must be possible to justify the effort
- energy savings will exist, but no monetary savings until the end of the project,
- a long term commitment is required, with termination liabilities should the facility close before the end of the ESPC term.

Alameda was the third Coast Guard experience with ESPC delivery orders. After performing interviews and a selection process, the Coast Guard decided to partner with Honeywell for West Coast Super ESPC delivery orders. The solicitation was not competitive. Honeywell originally proposed to do ESPC projects at 18 Coast Guard sites. Honeywell identified initial ECMs in Alameda, San Pedro, Seattle and Honolulu and approached the Coast Guard in 1997. After Coast Guard review, it was determined that Alameda was the best candidate for an the first Honeywell Super ESPC delivery order with the Coast Guard. In April, 1998, the initial proposal was received and negotiations on finalizing it began. The delivery order was signed in April 1999.

6.2. Project Description

The Coast Guard facilities in this project consist of several buildings at three different sites: Coast Guard Island in Alameda, a housing development at the former Naval Air Station in Alameda and a housing development in Novato. The buildings on Coast Guard Island house staff and equipment and are used in daily operations. The housing areas consist of numerous different types of units, from single family homes through 6-plex townhomes. The buildings are not large, and the climate where they are located is mild. Also, Alameda has relatively low electric rates. These factors lessen the opportunity for energy savings projects with reasonable payback periods and CG did not want to enter into a contract for longer than 10 years.

Honeywell originally proposed a broad range of measures at Alameda Coast Guard Station. These included: new boilers, steam isolation valves, EMCS, lighting upgrade, cogeneration plant, water conservation measures and programmable thermostats. The final delivery order proposal included: steam line isolation valves, EMCS, lighting upgrade and programmable thermostats. After the DO was signed, it was decided to remove the programmable thermostats in the housing areas. This was removed because of implementation problems with the measures, and other reasons, but not specifically due to M&V concerns.

Table 7 summarizes the ECMs, their costs and expected annual savings, and the M&V options used. Savings reported include operations and maintenance savings, and were obtained from the final delivery order H-schedules. The M&V cost shown is the entire cost, including the service phase margin, for the 10 year contract term. M&V costs were estimated on a time-and-materials basis for all ECMs, including those that will not be implemented.

Table 7: Coast Guard Alameda SuperESPC final proposal

Measure	Cost	Savings	M&V Method
ISC- EMCS	$226,370	$23,040 (O&M: $3,500)	A
ISC- Lighting	$316,501	$49,591 (O&M: $2,100)	A
Housing – HVAC/Water	$117,535	$14,594	A
Housing - Lighting	$455,846	$53,110	A
Total	$1,116,251	$140,335 (O&M: $5,600)	Annual M&V Cost $3,797

Synopses are provided for the only two ECMs to be implemented in the project: EMCS and lighting upgrade.

6.2.1. Energy Management and Control System

This was a measure specifically requested by Alameda staff. A direct digital control (DDC) EMCS was installed to automatically control the boilers, hot water pumps, and air handling units in eleven of the Coast Guard Island buildings. Programmable thermostats, timeclocks and HVAC controllers were installed to control the run-time of the existing heating systems equipment. The M&V plan does not provide a description of the number of control and monitoring points installed, but does describe the equipment in each building to be controlled (boilers, pumps and fans, etc.). Energy savings will be obtained from shutting off equipment during unoccupied hours, as well as by matching system loads with the conditioning needs of the facility.

This ECM resulted in $19,540/yr of energy savings, in addition to $3,500 a year in direct O&M savings. Honeywell will provide labor for all maintenance activities related to the EMCS for the duration of the project. This includes checks of software and occupancy schedules, proper operation of field panels, calibration of sensors, etc. Honeywell will also provide training and operations manuals to Coast Guard for the EMCS.

6.2.2. Lighting – Alameda Buildings and Novato Housing

This measure included a number of lighting upgrade projects, such as: retrofitting existing fluorescent lighting fixtures with energy efficient technology, replacing incandescent lamps with compact fluorescent lamps, and replacing existing mercury vapor systems with metal halide or high pressure sodium lighting. In addition, exit sign lamps were replaced with light-emitting diodes.

Other energy use reduction strategies outlined in the M&V plan included installation of lighting controls and reflectors, use of natural lighting, delamping and increasing the reflectivity of space surfaces. No further description of these measures were provided in the M&V plan.

Energy savings for the lighting measures accounted for $102,701 in annual dollar savings, of which $2,100 is O&M savings. No specific description of how O&M savings were estimated was found.

6.3. M&V Development Process

The initial M&V plan, dated October 1998, was provided by Honeywell shortly after completion of the detailed energy survey. It included all of the originally proposed ECMs. From the start of discussions to finalization the delivery order, discussion on the M&V plans were included. The final M&V plan was accepted with the signing of the delivery order in April, 1999.

The Coast Guard has a central office in Seattle with engineering staff for all of their facilities. Local staff in Alameda did not have the personnel or directive to negotiate DOs. Members of engineering staff from the Seattle office attended two-day FEMP training on measurement and verification before starting the DOs, and thus had a good understanding of the FEMP Guidelines, role of M&V and the M&V Options before developing the Alameda project. During negotiations, FEMP staff (Cheri Sayer, Mike Holda, and Steve Kromer) provided assistance to the Coast Guard.

The first proposal submitted did not include an M&V plan. General discussions on M&V included an Option B type plan for the cogeneration plant and the EMCS. A detailed energy survey was performed and a new proposal submitted in October, 1998 included a M&V plan that proposed Option A type methods for all of the ECMs. The M&V plan for all of the ECMs included in the final DO were also exclusively Option-A type methods.

Reasons cited for the Option A M&V methods were lower cost and appropriateness of the method for the lighting upgrade and programmable thermostat projects. Lt. Evans mentioned that he would have liked to see more Option B M&V associated with the EMCS, as in theory the EMCS could have been used for measurements. However, the energy savings generated from the EMCS was approximately $20,000 annually. This amount was not large enough to justify in-depth M&V activity. Table 8 compares the M&V Options included in the initial and final M&V plans.

Table 8. Comparison of initial and final M&V plans, by ECM.

ECM	Description	Initial Proposal M&V Option*	Final Proposal M&V Option**	Implemented ECMs M&V Options***
1	EMCS	A	A	A
2	Lighting – CG Island	A	A	A
3	Lighting – Novato Housing	A	A	A
4	Heating and Hot Water Boilers	A		
5	Steam Line Isolation Valves	A	A	
6	Generation Plant	B		
7	Water Conservation Projects	A		
8	Programmable Thermostats	A		

* October, 1998
** February 1999
*** based on interview with Lt. Dennis Evans, USCG

Review of the initial and final M&V plans did not show any noticeable changes other than the removal of several ECMs. For the EMCS measure, it appears that two building systems were removed from the scope of the project.

Schedule H-3 showed the line items which made up the annual contractor payments. It indicated a M&V budget for only five years. Lt. Evans also stated that M&V was only to be performed for five years. Total M&V costs were estimated to be $37,972 (including the service phase margin of 29.5%) over the life of the ESPC (10 yr.). Preventative maintenance is indicated for the entire duration and Honeywell's management plan indicated that the EMCS performance will be reviewed on an annual basis for the final five contract years as well.

6.4. Use of M&V Guidelines

M&V plans were developed for each ECM. Because the programmable thermostats will not be implemented, this review concentrates on the EMCS and the two lighting ECMs. The actual M&V plan types these three ECMs is Option A.

The FEMP M&V Guidelines have no explicit Option A type method for EMCS ECMs, but do have Option A methods for lighting efficiency methods. The Guidelines did provide a general description of Option A methods, which could be used to generate an EMCS M&V plan.

6.4.1. EMCS

The M&V plan for this ECM provided a brief overview of the method, indicated which buildings were affected, then provided tables of parameter values to be used in the calculations of baseline and post-installation energy savings. The equations for baseline and post-installation energy use calculations, as well as annual energy savings calculations, were shown.

Energy savings will be realized from shutting off equipment during unoccupied hours. For each boiler and motor controlled by the EMCS, the parameter tables showed data for boiler capacity and efficiency, and motor nameplate horsepower, load factor and efficiency. Data on annual operation hours for the boilers, pumps and fans were also listed, as were building occupied and unoccupied hours.

Energy savings will be calculated by subtracting the post-installation usage from the baseline usage, using all parameters identified in the tables. While all boiler and motor performance values (e.g. boiler capacity and efficiency, motor horsepower, load factor and efficiency) remain unchanged, operation hours for the equipment is reduced in the post-installation period.

Equipment performance and usage values to be used in the calculations appeared to be derived from nameplate information, or assumed. For example, the baseline and post-installation value tables indicated that boiler capacities and efficiencies were "measured, derived from nameplate information." Other assumptions included motor load factor (in every case, 70%) and post-installation operation hours. There was no indication of what measurements will be used to validate these assumptions, or verify the nameplate information. It was noted that boiler and motor change-outs were not planned, so in theory the performance values will be the same throughout the baseline and post-installation period. However, no indication of measurements for these parameters were indicated in the M&V plan, nor was information on measurement equipment, measurement intervals, or calibration schedules included.

The EMCS project accounted for 7.5% of the kWh savings and 100% of the therm savings of this project.

6.4.2. Lighting –Coast Guard Island Buildings and Housing

The lighting M&V plans were similar to the EMCS M&V plans. Each provided a brief overview of the method, indicated which buildings will be affected, and provided parameter value tables of variables to be used in the determination of savings. The equations for baseline and post-installation energy use calculations, as well as annual energy savings, were explicitly written out. Demand savings equations were also specified and written out.

Lighting energy savings are realized by upgrading lighting ballasts and lamps with more efficient equipment. In the Coast Guard Island buildings, additional savings will be realized by reducing operation hours through lighting controls, use of reflectors, delamping, and use of more natural lighting.

Parameters used to determine energy usage and demand savings included fixture wattages, fixture counts, and annual operating hours. The baseline and post-installation parameter tables indicated the source of the data, but did not include actual numerical values (unlike the EMCS parameter tables). Most values were contained in another part of the delivery order, presumably, in the detailed energy survey. The parameter tables also included the lighting levels, measured in foot-candles.

The M&V plan indicated that fixtures were separated into usage groups, and sample sizes were determined. Specific information about the usage groups and sample sizes was not included. The plan also indicated that measurements were made for approximately 10% of the existing fixtures. The plan indicated that the annual operating hours for each usage group were determined from occupant interviews, and Lt. Evans confirmed this. The plan stated no activity for measuring operation hours, either in the baseline or post-installation periods.

In the post-installation period, the plan indicated that total lighting system wattage will be determined from individual fixture wattages and quantities. Measurements of fixture wattages and foot-candle measurements will be made using the same sampling plan as in the baseline period.

The lighting projects accounted for 92.5% of the total kWh savings, and 100% of the kW savings of this project.

<u>General Comments on M&V plan</u>

The description of M&V activities were not clear, and conflicting information was found throughout each plan. The plans do not explicitly state which performance and operation parameters will be measured, and which will be obtained from nameplate information or assumed. Although Coast Guard staff indicated that significant effort to determine lighting circuit operation hours occurred, the M&V plan does not provide any basis, other than a short sentence, for justifying the operation hours.

In both M&V plans, it appeared that several assumptions were made, and these values will be used to calculate energy and demand savings. Examples include: nameplate capacities of boilers and motors, equipment operation hours, and motor load factors. While it may be true that several of these parameters will be measured (there is one oblique reference to measurements of some of these parameters), it is not evident from the M&V plan description.

6.5. Examination of Risks Associated with M&V Plans

A project's risk is associated with the uncertainty of the savings. M&V is used to reduce those risks, but its costs should be reasonable. Several factors influence the risk in a project: energy costs, performance of new equipment, usage of new equipment, proper definition of the baseline, appropriateness of the methodology to determine savings, and uncertainty of variables used to define the baseline and post-installation energy use and demand. A quantitative risk analysis was not possible, due to the lack of measured data. Instead, a general review of the methodology and measured variables provided a basis for a qualitative discussion of risk.

Energy costs were based on utility rates, and were constant for the term of the contract. Electricity and natural gas are provided by the local Utility, Alameda Bureau of Electricity, and appeared to be comparable with other local utility energy rates. If Coast Guard has a long term contract with the local utility with fixed rates, then the ESPC should be budget neutral (assuming savings are as expected). Increases in the energy rates increases the value of the energy savings, resulting in gains for Coast Guard, and conversely, decreases in energy rates reduces the energy savings value. This latter case should not present a risk, however, assuming the facility's energy budget remains the same.

The lighting ECM generated the majority of energy cost savings: 84%. Factors used in calculation of savings included lighting wattage and annual operation hours. It was indicated that lighting fixture wattages were determined from manufacturer data and measurements on a sample of fixtures, and that annual operation hours were stipulated, and based on interviews with facility staff. No measurements of annual operation hours were indicated.

In general, differences between manufacturer specifications and actual fixture wattages are on the order of 3 to 6%, while uncertainties associated with operation hours can be very large depending on the operation of the facilities. Operation hour estimates are the primary source of savings uncertainty, and thus risk, in lighting projects because they are hard to estimate in most cases. One way to reduce uncertainty in operation hour estimates is to focus measurement activities on operation hours rather than on fixture wattages. This can usually be justified in larger projects.

Because operation hours is a parameter that the ESCO does not typically control, a more common method is to review and agree upon the operation hours, which is the method employed here. This method shifts the risk to the Coast Guard. At Alameda Island facilities, which operate in regular schedules, estimates can be made with sufficient accuracy. This is typically not true for residential facilities, at least in tenant apartments. Estimates of operation hours would have a high degree of uncertainty, because of irregular schedules. The Novato housing facilities account for approximately half of the overall lighting savings. The predicted energy savings from these facilities likely have the highest degree of uncertainty.

Many assumptions were employed for equipment attached to the EMCS. While one sentence indicated that these variables will be measured, no information was provided as to how the parameters will be verified. For example, how will boiler capacity and efficiency be verified? A combustion efficiency test is typically used, but is not mentioned.

The equations used to calculate baseline and post-installation energy usage seemed overly cumbersome. Instead of using measurements of motor kW, the equations estimate kW through the motor horsepower, load factor and efficiency. It would be far simpler to use the kW measurements. This would also eliminate the uncertainty introduced by assumptions of boiler capacity, efficiency and motor load factor, etc. The plan indicated that measurements were made, but the stated calculation procedure did not reflect that these measurements would be used. Thus, there is a high degree of uncertainty in EMCS savings because equipment performance (kW, efficiency, etc.) and usage (load factor, operation hours, etc.) are not supported by measurements.

Again, because the EMCS savings were a small portion of the overall energy cost savings, extensive measurements may not have been justified. However, use of measured values obtained through the EMCS should be investigated, as it may be a low-cost method of obtaining measured data. Also, reducing reliance on the above-stated assumptions would be appropriate.

Measurement and verification activities were budgeted for only the first five years of the contract. Of the two ECMs installed, EMCS and lighting upgrades, annual energy savings amounted to approximately $120,000. The annual M&V activity costs were only 6.3% of the energy savings in the first five years (including the 29.5% service phase margin). However, over the term of the contract, the M&V budget was only 3.2% of energy savings. This seems low in comparison with the predicted energy savings to result from the project. Small M&V budgets limit the M&V activities that may be performed.

6.6. Other Comments

Coast Guard and Honeywell did try to limit M&V costs because project savings were small. Lt. Evans said that as Coast Guard sought to reduce the contract term, one of the areas reviewed was the M&V budget. One recommendation from LT. Evans was that in the Final Proposal, a more detailed line-item breakdown of M&V costs should be provided, so that negotiators know what M&V activities and costs are involved and what elements of the plan they want to keep. Currently, the final proposals tend to list only a lump sum annual M&V cost, versus a more useful detailing of specific components of that cost. It is difficult to negotiate M&V when there is not a detailed cost breakdown.

7. SITE 7: POINT MUGU — OXNARD, CA

Site Contacts:	David Crouch, Contracting Officer, NAVFAC Contracts Office David Schuelke, Electrical Engineer, Naval Facilities Engineering Service Center
Site Visit Date:	11/2/99
Schiller Representatives:	Lia Webster and David Jump
Documents Reviewed:	M&V plans: Initial (12/21/98) Final (6/18/99), Final H-schedules, Final O&M plan.

7.1. Project Motivation

The Navy's team for this project was based at Port Hueneme, in the Naval Facilities (NAVFAC) contracts office. The Navy's Construction Batallion is located in Port Hueneme, where there is also a large engineering staff office – the Naval Facilities Engineering Service Center (NFESC), an office of approximately 350 engineers. These offices provide contracting and engineering services to their "clients" which are other facilities and departments in the Navy. This office has developed several ESPC projects in the past. Teams are developed to implement projects, and they consist of staff members, usually facility managers, of the client departments, the contracts office and the engineering service center. They used the same approach for this SuperESPC project.

Use of the SuperESPC program was an idea that originated from the Naval headquarters office in Washington D.C. The contracting officer, David Crouch, and other representatives from Pt. Hueneme attended a FEMP-sponsored regional workshop in Las Vegas prior to developing this delivery order. Staff was already very familiar with ESPC projects from prior experience with both DOE and DOD programs. Pt. Mugu would be the Navy's first SuperESPC delivery order in the western region.

The primary motivation for the implementation of energy conservation projects at Point Mugu Naval Air Weapons Station[7] (Pt. Mugu) was to meet the Executive Order[8] to reduce energy consumption levels. A secondary motivation for energy projects was the procurement of new equipment. In past years, Congress has appropriated between 85 and 90 million dollars for Navy energy projects. For the current year, this budget was cut to zero, leaving the military with fewer contracting alternatives.

Other mechanisms available to the Navy for implementation of energy projects was utility funded DSM programs. Utility services for Pt. Mugu are provided by Southern California Edison (SCE). No utility incentives were provided for this project.

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[7] Ventura County Naval Base, Naval Construction Battalion Center, Naval Air Station, Port Mugu, Port Hueneme, CA 93401

[8] Executive Order released June 3, 1999 relating to the Energy policy Act of 1992 (EPACT) entitled *Greening the Government through Efficient Management.*

For this project, the energy manager for NAV-AIR[9] approached the Navy contracting officers to request a project. NAV-AIR specifically wanted a wind-diesel generation plant. The contracting office bundled NAV-AIR's projects with other local naval department's projects into one RFP, which was released in October 1998. The RFP included six buildings, three of which belong to NAV-AIR. A site data package with site-specific details was issued later that month, and contractor walk-through inspections were conducted. Four proposals were submitted, and two ESCOs were interviewed. The project was awarded to ERI[10], who then completed the detailed energy study in June 1999.

The final Delivery Order was signed in July 1999 for a term of 15 years. The Navy provided some additional incentives for the projects[11], which bought the contract down to a 13-year term. Staff favored a shorter contract. The installation of this project began in August 1999 and is scheduled to be complete by April 2000.

7.2. Project Description

The original site data package issued included at least six buildings on the Naval base. This project incorporated only three of those facilities. The other facilities, which are operated by different naval clients, were removed from the scope of this project and will be contracted under a separate Delivery Order. The reduction in DO scope was due the contracts office desire to limit the DO's payments between the ESCO and one client.

The issued DO covers work in three separate buildings (# 36, 761, and 7020) at Pt. Mugu. The primary energy saving measure involved modifications to HVAC systems, installation of an energy management and control system (EMCS), chiller and boiler plant improvements, as well as lighting system upgrades. The initial costs and annual energy and maintenance savings are shown in Table 9.

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[9] NAV Air: find out who these guys are. Talk to the facility manager Chris Karandang / Bob Faung @ 805-989-0797

[10] ERI Services, Inc. 350 Fairfield Avenue, Bridgeport, CT 06604

[11] Reportedly, the Navy will match 10% of funds spent on energy conservation projects up to $500,000

Table 9: SuperESPC Project Statistics: Point Mugu— Oxnard, California

Measure	Installed Cost (w/margin)	Annual Energy and O&M Cost Savings	M&V Method
HVAC Upgrades	$888,047	$116,584 (O&M: $58,948)	A
EMCS	$181,062	$56,764 (O&M: $3,270)	A
Chiller Plant	$299,026	$46,405 (O&M: $2,330)	A
Boiler Plant	$209,173	$31,404 (O&M: $7,552)	A
Lighting Retrofit & Controls	$102,788	$12,645 (O&M: $0)	A
Insulation of Heating Pipes	$10,907	$1,120 (O&M: $0)	A
Total:	**$1,691,003**	**$264,922 (Total O&M: 72,100, 27%)**	

The project originally called for installation of high-efficiency motors and a wind-diesel energy system. The wind-diesel generating system was eventually dropped from the scope because of cost effectiveness concerns.

7.2.1. HVAC Upgrades

This measure will replace ten older rooftop heating and ventilating units in building 761 with two new variable air volume (VAV) units. The new units will utilize the existing ductwork. Controls added for these VAV systems (see EMCS 7.2.2) included economizer operation, VFDs on both supply and return fans, and control of VAV zone dampers. This measure achieves both operational and maintenance savings, and comprised about 44% of the project's annual cost savings.

7.2.2. Energy Management and Control System (EMCS)

This measure included the installation of a direct digital control (DDC) energy management and control system (EMCS) in buildings 36, 761, and 7020. The EMCS will implement the following energy management strategies:

- Scheduled start/stop of HVAC equipment with night set-back in non-critical areas
- Reduced outdoor air intake through repair of controls for dampers
- Temperature reset in multi-zone HVAC units
- Chiller plant optimization (see 7.2.3)
- Boiler optimization (see 7.2.4)

The savings from this measure will comprise about 21% of the project's annual cost savings.

7.2.3. Chiller Plant Modifications

The chiller plant serving buildings 761 and 7020 will be modified for more efficient operation.

- An adjustable frequency drive (AFD) will be installed on building 761 for improved chiller efficiency at part load conditions.

- Pumping system modifications included piping changes along with the removal of eight existing chilled water pumps and the installation of one new condenser water pump.
- EMCS system installation (see 7.2.2) will implement chilled water reset and condenser water reset control strategies

The savings from this measure comprised about 17% of the project's annual cost savings.

7.2.4. Boiler Plant Modifications

This measure included work in three separate buildings — 36, 761, and 7020. System changes included:

- Installation of one new boiler and 2 new pumps
- Decommissioning (standby) of one existing boiler and 2 existing pumps
- Cross connecting existing heating systems, including changes to valving
- Insulating two existing boilers
- Implementing boiler control strategies: scheduled unoccupied times; hot water temperature reset

The savings from this measure comprised about 12% of the project's annual cost savings.

7.2.5. Lighting Retrofit and Controls

Most of the areas within the facilities had energy efficient lighting installed prior to this project. The lighting systems in the remaining areas, primarily in Building 7020, will be upgraded with energy efficient equipment.

Occupancy sensors will be installed in some areas, primarily private offices and conference rooms, to reduce lighting operating hours. More than 300 occupancy sensors will be installed in buildings 36 and 7020.

The savings from this measure comprised less than 5% of the project's annual cost savings.

7.2.6. Insulation of Heating System

The heating hot water delivery pipes serving buildings 36 and 761 will be insulated. Savings were estimated on system specifications and common engineering calculations. Annual cost savings were very small.

7.3. M&V Development Process

Site-specific and ECM-specific M&V plans were developed by ERI before the detailed energy survey. For the chiller plant upgrade, EMCS and HVAC upgrade, ERI proposed Option C – type M&V, and proposed Option A for the rest of the measures. Table 10 shows the M&V options initially proposed and those included in the final DO.

Table 10. Comparison of initial and final M&V plans, by ECM

ECM	Description	Initial Proposal M&V Option	Final Proposal M&V Option
1	HVAC upgrade	C*	A
2	EMCS	C	A
3	Chiller plant upgrade	C	A
4	Boiler plant upgrade	A	A
5	Lighting retrofit and controls	A	A
6	Insulate heating system	A	A
7	High efficiency motors	A	n/a
8	Wind-diesel plant	A	n/a

* Option C indicates computer modeling of the buildings using spreadsheet analysis.

ERI originally identified eight ECMs for NAV-AIR, including the wind-diesel generation plant. Initially, NAV-AIR was less concerned about the role of M&V in the contract, as it had only requested one ECM. However, the NAV AIR staff[12] became closely involved during the contract development process, and participated in the development of the M&V plan. The contracts officers reported that in general, their clients are less concerned with M&V than they are.

One engineer for the Pt. Mugu project explained that he preferred to use the simplest M&V Option justified for the measure, as recommended in the Guidelines. His contractor had proposed extensive monitoring for a lighting project, which he believed could be handled with appropriate application of stipulations. He indicated that this particular project did not merit the rigor and associated cost of the proposed Option B methodology. He was not opposed to using more rigorous M&V, but stated that it should be justified by the measure.

The assigned Navy review engineer[13] requested to ERI during the development of the contract that equipment measurements be used as much as possible, while keeping the model as simple as possible. The contracting officers preferred that less modeling be used to determine the savings, and more direct calculations from measurements be used instead. In the proposed Option C – type M&V, not enough emphasis on measurement of ongoing operation and performance was perceived. Part of the contracting officer’s motivation was also to reduce the amount of review required to understand the model’s predictions of savings. The spreadsheet models developed by ERI were reviewed by FEMP personnel only.

Navy representatives preferred to see performance measurements along with conservative operating conditions and utility rates stipulated in the contracts wherever possible. They feel that an Option A approach reduced M&V efforts and costs, while ensuring savings. Extensive M&V efforts were not necessarily required to prove the enhanced performance of equipment and systems, depending on the desires of the individual facility owner. The Navy contracting personnel also indicated that they generally like to see M&V costs based on

[12] Facilities staff includes Chris Karandand and Bob Faung. Chris Karandang, Site technical representative, Ventura County Naval Base, 1000 23rd Ave. Code PW310, Construction battalion Center, Point Mugu Site, Bldg 67, Port Hueneme, CA 93041

[13] David Schuelke, Electrical Engineer, Energy Applications Division, Naval Facilities Engineering Service Center, Code ESC22; 1100 23RD Avenue; Port Hueneme, CA 90343-4370; phone 805-982-35010, fax 805-982-5388

time and materials for the contractor, and those costs range from 1 to 5% of savings. One of the goals in keeping M&V costs minimized is to keep the term of the contract as short as possible.

At least two conference calls were conducted during the Pt. Mugu contract development process during which questions regarding the M&V plans were addressed in detail. The site representative, the Navy contracting officers, and the FEMP representative participated in these discussions. It was settled that measurement of the baseline for these measures was prohibitive, and should be modeled. All parties agreed to the M&V plans.

7.4. Use of M&V Guidelines

The contracting staff and the facility staff attended FEMP training sessions, and were familiar with performance contracting concepts. In addition, the same contracting team is responsible for contracting all Navy and Marine SuperESPC projects. The Pt. Mugu contract was the first they have implemented in the Western region, but they have done several SuperESPC projects elsewhere and others are in development. The FEMP Guidelines have been applied to all of their performance contracting projects (some through DOD, not DOE or FEMP). The contracting officers did not recollect many of the details of this specific project, so their general approach to M&V was discussed.

The contractor, ERI, is familiar with FEMP and other M&V protocols, and provided a comprehensive description of the goals of M&V in their proposed plans, which were included as a part of the Delivery Order. ERI provided its M&V plan in two parts: an overview discussion of M&V, which described M&V activities common to all of the ECMs, and discussions of specific M&V activities for each ECM.

The M&V plan was very comprehensive in covering all of the FEMP-Guideline recommended elements of an M&V plan. In addition, the M&V plan offered good discussion on many of the salient points it considered in developing the M&V plan, such as its criteria for M&V plan selection, methods of analysis, and quality control of collected data. While these were general discussions, they were clearly written and provided a firm basis for discussing and negotiating M&V requirements for the project. The M&V plans were initially proposed in December, 1998, and were not further developed until after the detailed energy survey was performed in June 1999. The final delivery order was signed in July 1999. Staff reported that numerous discussion on M&V occurred over approximately two months.

ERI initially developed a number of spreadsheet models that were used to calculate the project's energy savings. The performance models, in most cases, were calibrated with system measurements and checked against historical utility data for accuracy. These Option C-type methods were revised to Option A methods, however the savings were still determined by the spreadsheet analysis in most cases. For most of the ECMs, savings determined in the first year will be used in following years, subject to verification that the equipment is performing to specifications.

7.4.1. HVAC Upgrades

This measure consisted of the replacement of several HVAC units with two variable volume units. The energy savings are achieved through reduced fan power, heating requirements, and cooling loads.

A model of the building was developed, which included details of the existing mechanical systems. Measured motor loads and other system parameters from the old HVAC systems were included in the model. Known hours of operation and historical weather data were applied to determine the annual heating and cooling loads. The performances of the old and new systems[14] were included, and then the two models were compared to determine annual energy savings.

7.4.2. Energy Management and Control System (EMCS)

This measure involved changes to several separate control systems, and did not lend itself to metering the actual system operations. The savings from the controls associated with the chiller plant upgrade were described in section 7.2.3, and the boiler plant controls were described in section 7.2.4. The additional control measures included:

- Setback of air handling units (AHUs) and outside-air dampers during unoccupied periods
- Operation of outside-air economizers

The energy savings resulting from these additional measures were calculated from spreadsheet models. Fan performance measurements were used to calibrate the model, and operating hours were stipulated. The proper operation of the control measures will be verified once they are implemented. Savings are based on the one-time spreadsheet calculation.

7.4.3. Chiller Plant Upgrade

The performance of the chiller plant serving buildings 761 and 7020 was improved through the installation of adjustable frequency drives, increased chilled water temperature set point, condenser water reset, and pumping system changes.

ERI developed spreadsheet models to describe the performance of the chiller plant systems before and after the modifications. Short-term metering of chiller performance was conducted. This data was correlated to outside air temperature, and the facility loading was determined. The chiller load is primarily driven by internal demands and is relatively constant. The loads for occupied and unoccupied building conditions were determined. The performances of the pumps were measured before and after the upgrades. This collected data along with utility bills were used to verify the model, and stipulated operating hours were applied to determine annual savings.

7.4.4. Boiler Plant Modifications

The majority of the savings from this measure come from the installation of smaller high efficiency boiler and circulation pumps and the de-commissioning of over-sized equipment.

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[14] Is this system installed yet? How did they measure post fan performance? Estimate by manufacturer?

Additional savings are achieved through hot water temperature reset, start/stop control, and insulating existing equipment.

ERI developed spreadsheet models of the boiler system operations both before and after the system modifications. Heating loads were calculated, and information from boiler logs and operating guidelines from facility staff were included in the models. The boiler plant efficiencies were stipulated based on typical industry standards of performance, and were degraded based on equipment age.

After installation is complete, short-term verification of proper system operations are planned, including inspections of equipment operations and EMCS trend logging of equipment performance.

7.4.5. Lighting Retrofit and Controls

The lighting energy savings are achieved through the installation of energy efficient lighting equipment, as well as occupancy controls.

The operating hours before and after the project are stipulated in the contract, including the reduction in hours resulting from the occupancy sensors. Reportedly, conservative estimates were used for operating hours and for the reduction in lighting hours. Some demand savings were claimed from the occupancy sensors from coincident decrease in lighting operating hours.

The performance (kW) of the lighting fixtures was spot-measured before and after the installation of new equipment. Statistically valid samples, meeting FEMP Guideline recommendations, were used.

7.4.6. Insulation of Heating System

The energy savings were stipulated using engineering calculations including system parameters such as the size of piping, length of each pipe run, system operating temperatures[15], and operating hours. The annual savings associated with this measure are negligible.

7.5. Examination of Risks Associated with M&V Plans

The top three energy savings ECMs in this project are the HVAC upgrade, EMCS installation and chiller plant upgrade, accounting for $155,205 of the estimated $192,822 energy savings in the project (80%). These three measures are also the top-ranking O&M savings measures, which provide an additional $64,549 of the total $72,100 O&M savings in the project. The HVAC upgrade provides $58,948 O&M savings alone.

The M&V plans for each of these three ECMs have the same general activities. A spreadsheet model of the baseline buildings and systems was created, a model of the post-installation buildings and systems will be created, and the savings will be determined from

[15] The surface temperate was documented at 320 degrees rather than 170 degrees. This discrepancy is minor.

the difference in energy use and demand predicted by the two models. The first-year savings will be used as the stipulated savings for the remaining term of the contract, pending verification of ECM performance. The contract values are likely to change based on the first year's savings.

M&V is concerned with minimizing the risk that the savings paid for are actually realized. One way to minimize risk is to minimize the uncertainty of the calculated savings. In this project, there are several potential sources of uncertainty. The main sources are: accuracy and validity of the models used, establishment of the baseline, and accurately representing the post-installation building systems. Each of these sources are discussed below along with the M&V plan's method of addressing it.

<u>Accuracy and validity of models used</u>:
Detailed drawings and descriptions of the buildings and systems were not among the documents reviewed, so no statement of the relevance or validity of the spreadsheet equations used to model the buildings will be discussed. The spreadsheet model was reportedly reviewed during contract negotiations.

Model accuracy is addressed in the M&V plans. Model accuracy is partly insured by its calibration. Calibration involves comparing the models predicted energy usage with that from measured data, usually utility bills. There are several degrees of rigor in calibrating a model. It can be calibrated by comparing its total annual energy use with the annual energy use obtained from the utility bills. Monthly utility bill data can be compared against model monthly energy predictions. The variation between the model's predicted monthly energy use and the monthly utility bills can also be minimized as an additional criteria. Measured data for each subsystem may also be compared with the model predictions of subsystems energy use. This is important when models are used to determine savings for individual ECMs, as is the case here. The M&V plans for the three ECMs compare model predictions with utility bills on an annual basis, and compare subsystems energy use with measured data (for the baseline case) and consider the models calibrated when the comparison is within 10% (for the chiller plant the calibration was achieved within 5%).

<u>Accurately representing the post-installation building systems</u>
In post-installation years, the M&V plans state that measurements of new equipment performance will be made, and used to modify the building model. The model predictions will be calibrated in the same way as the baseline case. Energy savings will be determine from the difference between the baseline model and post-installation model usage predictions. Because the models and subsystems will be calibrated, the predicted saving should be reasonably accurate. These savings predictions will be used for the remainder of the contract, subject to verifications on equipment performance. While the equipment performance will be verified, if the facility changes usage, or if there is an extreme weather year, there is risk that the stipulated savings overestimates the actual savings. However, the ESCO will not be responsible for the facility usage, and this risk is rightly borne by the Navy.

The HVAC upgrades account for the most cost savings from the project. Models used additional chiller loads, which pre-adjusted the baseline to account for planned upcoming changes that will increase chiller loads.

ERI will do annual utility bill analysis to verify the persistence of the energy savings. It will be their responsibility to identify any variances, and readjust the baseline as required annually.

7.6. Other Comments

- The summary descriptions of methods A, B, C, & D are helpful.
- Specific M&V training coming up for David Crouch. He had general FEMP training before. The Nav Air staff also attended SuperESPC training, which did help during the contracting process.
- The Navy has ample engineering resources. They used the FEMP resources offered because they were free. They do have to pay an internal cost to Navy engineers, but that is easier than funding to FEMP. Using the FEMP contract costs $10,000 with FEMP costs up to $50,000 depending on level of project involvement.
- The Navy utilized the services of FEMP personnel since their services were offered free of charge since this was the Navy's first SuperESPC project in the Western Region. Mike Holda and Steve Kromer were involved in the review of the M&V plans for this project.