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Subcontractor Report

Initial Application of the FEMP Measurement & Verification Guidelines in Super ESPC Delivery Orders

Final Report
May 2000

David Jump and Mark Stetz
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Oakland, California

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

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1 Executive Summary

Schiller Associates examined the measurement and verification (M&V) plans and activities for seven Western Region Super Energy Savings Performance Contract (ESPC) projects to learn how federal agencies are implementing M&V and what factors influence M&V plan development. This report describes the method used to examine the M&V plans and presents our findings. Our goals were to find common factors that influenced M&V plan development and implementation, assess risks to the agency as a result of particular M&V plans, and develop recommendations for improving M&V plan development and implementation. Participating agencies and sites were:

- National Park Service (NPS)—Yosemite National Park, CA
- Veterans Affairs (VA)—VA Medical Center, San Francisco, CA
- United States Forest Service (USFS)—USFS Laboratory, Corvallis, OR
- Federal Aviation Administration (FAA)—ATRCC, Auburn, WA
- United States Department of Defense (DOD)—Defense Manpower Data Center (DMDC), Monterey, CA
- United States Coast Guard (USCG)—Coast Guard Station, Alameda, CA
- United States Navy—Pt. Mugu, Oxnard, CA

Common themes and influences among the projects were observed. The most notable finding was the predominance of Option A (stipulated savings) in the M&V plans, sometimes implemented without any measurement or annual verification activities. The primary reason for using this method is its low cost. Because agencies pay for M&V services, simplified M&V plans are used to reduce costs so that contract terms will fit within acceptable limits. The primary driver for more rigorous M&V approaches is project motivation—agencies interested in reducing energy use are more likely to demand rigorous M&V methods than those agencies whose interest in new equipment is their primary motivation for a Super ESPC project.

While all agencies were aware of the risks inherent in performance contracts, only a few used M&V as a way to mitigate those risks. Some agencies felt that the risks were sufficiently low and that the added expense of M&V activities was not justified. A few desired the reassurance offered by M&V services, but were unable to pay for them. Agencies interested primarily in reducing their energy consumption were willing to pay for more rigorous M&V services. Annual expenses for M&V activities ranged between 2% and 14% of the annual savings, but expenses (as a ratio) did not correlate to capital cost or project savings.

Because of the large use of stipulated savings and occasionally unverified assumptions, the resulting M&V plans leave many agencies at risk in the event of unrealized savings. Although Super ESPC contracts provide for guaranteed savings, the lack of adequate verification activities reduces the value of a guarantee.

Our recommendations for improving M&V planning and implementation are:

1. Clarify the M&V option and method definitions and other terms used in the Federal Energy Management Program (FEMP) M&V Guidelines.
2. Distinguish between equipment performance (e.g., efficiency, capacity ratings) and equipment usage (e.g., operating hours, annual energy consumption) and their relationship to savings.

3. Provide recommendations as to which M&V options and methods should be used with different types of measures, based on project technologies, risks, and value.
4. Clarify use of stipulations for M&V Option A.
5. Develop M&V requirements for operations and maintenance (O&M) measures.
6. Provide additional training on M&V and develop in-house FEMP M&V expertise.
7. Require that M&V costs be estimated for each individual or group of measures.
8. Integrate the discussion of M&V with the selection of energy conservation measures (ECMs) when finalizing delivery orders (DOs).
9. Develop a standard framework for M&V plan content and evaluation.
10. Provide information on requirements associated with meeting federal ESPC regulations.
11. Develop sample M&V plans and reports.

2 Introduction

2.1 Report Objectives

This report presents the findings of a review of measurement and verification (M&V) plans for seven Western Region Super Energy Savings Performance Contract (ESPC) projects and an examination of how federal agencies are implementing M&V. Although the Federal Energy Management Program (FEMP) M&V guideline describes how M&V might be performed for various types of projects, it leaves considerable room for judgement and interpretation. Because of this, FEMP staff expressed concern that the implementation of M&V may not be consistent or conform to the FEMP M&V Guideline's intent. Thus, we evaluated the most common M&V approaches among the involved projects and the factors that influenced the development of the M&V plans.

Several factors were hypothesized to have a significant influence on the quality and rigor of a project's M&V plan: participant attitudes and motivations, economic and logistical factors, an understanding of ESPCs, and the associated role of M&V. Our goals were to determine the common influences that shaped M&V activities, to compare the planned implementation of M&V with its intended role, and to identify shortcomings and innovative approaches in implementing M&V. We also assessed typical project risks and the role of M&V in allocating those risks. Lastly, based on these findings and risk assessments, we made recommendations to help improve the quality and practice of M&V activities in Super ESPC projects.

In Super ESPC projects, savings M&V is a way to allocate and mitigate the risk to both the federal agency and to the energy services company (ESCO). Performance contracts are implemented based on estimated savings. Super ESPC legislation requires M&V to document the level of savings actually achieved. Common reasons why savings may not materialize are as follows: (1) the savings estimates may not be accurate; (2) the installed equipment may not be working correctly; or (3) equipment usage may be different than originally assumed. A project that fails to produce savings presents a risk to both the agency and to the ESCO. Without performing post-installation M&V activities, there is no way of knowing whether these situations are occurring.

Super ESPC projects are guaranteed savings contracts under which M&V must demonstrate that savings meet or exceed a threshold amount—the actual savings are less relevant. This influences the accuracy requirements for savings estimation. While Super ESPC projects involve guaranteed savings, the guarantees are, in part, only as good as the methods used to verify them. ESCOs must exert some effort through M&V to show that savings are real (and greater than the guaranteed amounts) if the guarantees are to have any value. If the M&V results show that savings are less than the guaranteed amounts, then the ESCO must be liable for the shortfall.

2.2 Report Organization

This report describes the method used to survey the M&V plans of the participating agencies, and it presents our findings. Section 3 describes the methodology used for the project, and Section 4 summarizes our findings. In Section 5, typical project risks are assessed and discussed as a background to providing specific recommendations. Based on our findings and the risk assessment discussion, specific recommendations for improving and simplifying the M&V development process are made in Section 6. The Appendix contains interview questions and individual site reports from seven Western Region agencies as supporting material.

3 Methodology

Schiller Associates reviewed the seven Super ESPC projects to become familiar with them and to review the documented development of the M&V plans. Cheri Sayer, a western region contact for the Super ESPC program, invited Schiller Associates staff members to review proposal documents at the Seattle Department of Energy (DOE) office to learn more about the projects and M&V plan development. She and Tim Kehrli, who also participated in many of the projects as a submittal reviewer and facilitator, discussed their experiences and opinions. From this information, and from discussions with Doug Dahle of the National Renewable Energy Laboratory (NREL), and Mike Holda and Steve Kromer of Lawrence Berkeley National Laboratory (LBNL), we developed a list of common questions to use as the basis for interviews with agency staff members responsible for implementing the projects (this list is included in Appendix A). We forwarded this list to each site prior to visiting so that staff would understand what we were seeking and would have time to research the answers. We then held interviews with agency personnel in an effort to learn more about how M&V plans were developed, what their attitudes were toward M&V, and whether planned M&V efforts were commensurate with the project.

The seven federal agencies that agreed to participate in this survey included a cross-section of facility types, project types, and ESCOs. Each of the surveyed agencies had recently finalized the DOs and was in the process of installing the ECMs. Two Schiller Associates staff members reviewed M&V plans and visited five of the sites to meet with the contracting officers and other involved personnel. Staff members associated with two other sites were interviewed via telephone conference call. Table 1 lists the participating agencies and the associated sites and ESCOs.

Table 1: Participating Western Region Agencies

Agency	Location	ESCO
National Park Service	Yosemite National Park, Yosemite, CA	BMP
Veteran's Affairs	VAMC, San Francisco, CA	Johnson Controls
Forest Service	USFS Laboratory, Corvallis, OR	Honeywell
Federal Aviation Administration	ATRCC, Auburn, WA	Johnson Controls
Defense Department	Defense Manpower Data Center, Monterey, CA	Sempra
Coast Guard	Coast Guard Station, Alameda, CA	Honeywell
Navy	Pt. Mugu, Oxnard, CA	ERI

Many of these sites had comprehensive retrofits performed. Technologies included boilers, chillers, variable-frequency drive (VFD) additions, efficient motors, controls upgrades, lighting, air compressors, heating, ventilating, and air-conditioning (HVAC) modifications, and steam and hot-water system improvements. Sites were chosen with DOs that included a broad array of technology categories and that were of different contract funding amounts to see what variations existed in the final M&V plans. This approach would also help us determine how project cost, measure risk, or other factors influenced M&V plan development. The visiting teams then wrote reports that summarized their findings. From these reports, we sought common themes and results.

4 Summary of Findings

The survey of M&V plans and interviews with agency staff members at the seven sites revealed a great deal of relevant information. The findings could be summarized into four general categories: project motivations, M&V implementation, M&V implementation costs, and M&V development influences. The following four subsections present these findings.

4.1 Project Motivations

4.1.1 Common Motives among Agencies

The most common motives for using Super ESPC were the following:

- To obtain new equipment
- To reduce energy costs
- To comply with Energy Policy Act (EPACT) and Executive Orders[1].

Most projects involved a combination of motives; few agencies used the Super ESPC program for a single reason. In some cases, existing mechanical equipment was near the end of its useful life and a cash-strapped agency needed to find a way to purchase new equipment. That the new equipment would work better and provide energy savings was an added bonus. Other agencies primarily sought financial savings, either from reduced energy consumption or through reduced operations and maintenance expenses, which accompany new equipment.

4.1.2 Reasons for Selecting Super ESPC Over Other Available Contract Means

Some agencies considered other available contracting mechanisms for acquiring new equipment (e.g., the Defense Manpower Data Center (DMDC), Pt. Mugu, Coast Guard). However, the Super ESPC Program was a more attractive option for several reasons: the contractors were pre-qualified, a support team was available to help negotiate and finalize DOs, and, generally, more measures and equipment than the agencies originally planned could be included. Lt. Dennis Evans of the Coast Guard said that, initially, the Super ESPC was attractive because the ESCO would be responsible for verifying the savings, thus allowing the Coast Guard to consider more risky projects because the risk would be shared. Our reason for questioning the agencies about contracting options was to see if the existence of M&V in Super ESPC was an attractive aspect of or a deciding factor in choosing the Super ESPC. None of the agencies reported M&V as their primary motivation for choosing Super ESPC.

4.1.3 Project Marketing

Project marketing was evenly divided between ESCOs, contacting agencies, and agencies directed to ESCOs by DOE. Many of the projects examined occurred early in the Super ESPC program when it was common for DOE to approach an agency about trying the program. Some of the ESCOs (e.g., Honeywell and Johnson Controls) used the Super ESPC program as a mechanism for continuing work with their existing clients.

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[1] Energy Policy Act of 1992 and Executive Orders 12902 and 13123.

4.1.4 Competition Effects

At three agencies—Pt. Mugu, the Federal Aviation Administration (FAA), and DMDC—the contractors were competitively selected. At the other four, each agency used the ESCO that originally approached them to implement the project. It was common among all projects for the agency and the ESCO to jointly identify measures that would go into a project. Most agencies had a small "wish list'" of items that they wanted, while the ESCOs sought measures that would make the project economically viable. In this sense, most projects were collaboratively developed. None of the three agencies that competitively solicited their projects reported selecting one ESCO over another based on the quality of the proposed M&V plan. Other factors, such as the number of measures, price, and the agency's confidence in the ESCO's ability to perform, were more important.

4.1.5 Project Bundling

All projects were comprehensive and had at least two measures. Savings from lighting measures often subsidized other desired measures. At the San Francisco VA Medical Center (VAMC), operations and maintenance (O&M) savings from displaced labor[2] were used to subsidize upgrades in the boiler, energy management and control system (EMCS), and air compressor. At Yosemite, an electrical distribution upgrade was the major contributor to savings. It made them eligible for a lower utility rate and made the boiler and VFD installations possible.

Very few projects involved technology conversions, such as replacing centrifugal chillers with absorption chillers. Some sites installed new equipment, such as variable speed drives and EMCS, that did not replace existing equipment. The EMCS projects at two sites were upgrades of existing systems; however, most measures replaced existing equipment with new, more efficient equipment of a similar type and size.

4.1.6 M&V Option Motivations

Clear motivations for choosing certain M&V options over others were identified, as several agencies did discuss their preferences. A naval engineer for the Pt. Mugu project explained that he preferred to use the simplest M&V option justified for the measure. 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 at all opposed to using more rigorous M&V, but stated that it should be justified by the measure.

A U.S. Coast Guard (USCG) engineer involved in the Alameda Coast Guard Station project preferred Option B methods because he believed it provided firm data to support the savings calculations. One of the measures was an EMCS, which would be used to monitor the other measures in the project. He hoped that the EMCS could be used to reduce the costs of Option B measurements. Ultimately, the relatively small savings of the Alameda project did not justify Option B methods even with the EMCS, and an Option A approach was adopted instead.

At Yosemite, National Park Service (NPS) staff wanted Option B for two of the highest energy-savings projects: VFD installations on the wastewater treatment plant pumps and on air-handling unit (AHU) fans in the visitor center HVAC system. The savings did not justify the costs of the proposed Option B

[2] 5.2 full-time equivalent employees.

measurements. The solution was for NPS to do the monitoring outside the ESPC DO; and the ESCO, Bentley, agreed to use the results when calculating savings. Funding for the meters and installation was provided through DOE.

4.2 M&V Implementation

A summary of ECMs, M&V options, and DO contract data is provided in Table 2. The table shows the ECMs installed (or to be installed) at each site and the corresponding selected M&V option. All seven agencies implemented lighting measures and six of them implemented EMCS. Four sites implemented boiler plant measures; other measures were common to three or fewer agencies.

Table 2. Measure and Contract Information for Each Agency

	NPS, Yosemite, CA	**VA, San Francisco, CA**	**Forest Service, Corvallis, OR**	**FAA, Auburn, WA**	**DMDC, Monterey, CA**	**Coast Guard, Alameda, CA**	**Pt. Mugu, Oxnard, CA**
	Bentley	JCI	Honeywell	JCI	Sempra	Honeywell	ERI
Lighting	A	A	A	A	A	A	A
EMCS	A	A	B&C		B → A	A	A
Boiler/Plant Upgrade	A	B			Gas: C → A KWh: B → A		A (plant only)
HVAC • VAV conversion • Repl. Cooling Coil • Economizer	B → A A	A			B → A		A
Steam/Hot Water System Upgrades			A		A		A
Chiller/Plant Upgrade				B			A
Motor Efficiency		B			A		
Install VFDs	B → A						
Air Compressors		B					
Project Capital Cost	$584,535	$4,428,666	$394,000	$332,310	$2,142,880	$998,717	$1,619,003
Energy Savings	$34,206	$208,774	$63,000	$50,271	$369,911	$120,141	$264,922
O&M (and Other) Savings	$48,157[3]	$319,950	$14,000	-0-	$53,240	$5,600	$72,000
Contract Term–years	14	19	10	15	9	10	13
Annual M&V Cost[4]	$4,577	$25,286	$6,700	$6,900	$20,051	$3,797[5]	$5,529
Total M&V Cost	$64,078	$480,434	$67,000	$103,500	$180,459	$37,970	$71,877
Service Phase Margin	25%	27.9%	29.5%	27.9%	18%	29.5%	17.3%
Annual M&V Cost/ Energy Savings	13%	12%	11%	14%	5%	3%	2%
Total M&V Cost/ Project Cap. Cost	11%	11%	17%	31%	8%	4%	4%

[3] Savings from an electric rate change.
[4] Average values based on data reported in H-3 schedules and include service phase margin.
[5] Average M&V cost over ten years. Contract specified only five years of M&V.

The dominant M&V option named in the projects was Option A. This is true for all of the lighting ECMs, and for most other ECMs as well. There were several interpretations of the M&V options, which will be discussed below. In a few cases, as shown in Table 2, combinations of options were used. For example, Option B or C methods were used in the first post-installation year to determine savings, with results used as stipulations (Option A) for succeeding years, subject to equipment performance checks (in Table 2, these cases are shown with an arrow). Such combinations are innovative uses of the options (they are not specifically described in the FEMP M&V Guideline).

The most common finding was the heavy reliance on Option A with stipulated values as an M&V approach. In some cases, it appeared that "stipulation" was interpreted to mean that the two parties would agree to savings estimates prior to measure installation and that no baseline measurements or verification would be used and no post-retrofit verification, measurement, or analysis work would be performed. This interpretation is contrary to the intent of the FEMP M&V Guideline and may not adequately verify savings as required by Super ESPC legislation. This interpretation and implementation of Option A was not limited to lighting projects, but was used for a broad range of measures, including complex measures with variable loads or operating schedules. While Option A is allowed by the FEMP M&V Guideline, the proper use of Option A requires baseline, post-installation, and annual verification inspections and the use of at least some actual on-site measurements and/or analysis to support stipulated values.

This finding is related to another important finding, which is that the agency's motivation for implementing a project was the single largest factor in determining the level of rigor used in M&V development and implementation. Agencies that used the Super ESPC program to reduce energy costs were interested in quantifying their savings; agencies that were motivated by obtaining new equipment were less interested in quantifying their savings.

As an example of how stipulations were used, Option A for lighting (LE-A-01) calls for using totally stipulated values (no measurements), while the more rigorous method (LE-A-02) calls for taking sample measurements of fixture power both before and after a retrofit. Both variations call for performing some verification work on an annual basis after the project is installed. "Stipulation" is intended to mean that the two parties agree upon factors used in the savings estimates based on measurements or on sound use of historical data for the project in question. The most common approach was to measure a sample of fixtures to determine power consumption (pre- and post-retrofit) while agreeing to an operating hour schedule. Even with this arrangement, uncertainty still exists. At the United States Forest Service (USFS) laboratory, Honeywell measured fixture powers *after* installation, but had not adequately measured the existing fixtures prior to their removal. Because the baseline power level had a high degree of uncertainty, so did the savings estimates. At some sites, no measurements were taken and no annual verification activities will be performed. Without measurements or annual inspections, the stipulated values used to estimate savings introduce uncertainty into the savings estimates.

To illustrate how Option A was interpreted and implemented, Table 3 shows the lighting M&V approach for all seven sites. The use of Option A without measurements had no correlation to the size of the project—totally stipulated values were used on both the smallest and largest projects. Only three of the smaller projects specifically called for annual verification activities.

Table 3. M&V Approach for Lighting at All Seven Sites

Agency	Lighting Savings	M&V Method	Measured Values	Stipulated Values	Annual Verification
National Park Service	$8,500	A	None	Hours, Power	None
Veteran's Affairs	$121,000	A	Power	Hours	None
Forest Service	$27,000	A	Power	Hours	None
Federal Aviation Administration	$18,000	A	Power	Hours	Power
Defense Military Data Center	$16,000	A	Hours	Power	Hours
Coast Guard	$103,000	A	None	Hours, Power	None
Navy	$12,000	A	Power	Hours	Hours

The reason for using stipulated values was usually cost—the agency pays for the ESCO's M&V services and both the agencies and the ESCOs often felt that there was little value in spending money on lighting M&V services. Using stipulated values (sometimes with no supporting measurements) reduced the overall project cost, although it meant that the agency would be assuming more risk. This was an important consideration because, even though the risk of not realizing savings from lighting retrofits was low, the savings projected from lighting retrofits often subsidized the balance of the project. This experience with lighting measures was representative of other measures.

Another example of stipulated values unsupported by measurements was the stipulation of motor load factors at the Alameda Coast Guard Station. Load factors were assumed to be 70% uniformly for all motors connected to the EMCS. The motor kW used in the calculations was determined from nameplate motor efficiency, horsepower, and the assumed load factor.

Project motivation determined how much the agency was willing to pay for M&V services. Risk was usually not an issue with agencies seeking to obtain new equipment—they perceived a greater risk from failing to replace the equipment than from any uncertainty in the savings estimates. Agencies interested in reducing operating expenses were more interested in M&V services to ensure that savings would materialize and to quantify the amount of savings. These agencies were more concerned with project risk and were willing to spend a little more on M&V services.

To illustrate how project motivation affects M&V rigor, a comparison of M&V methods at the six sites where EMCS systems were installed is presented in Table 4. Savings from EMCS measures are often difficult to estimate and stipulating savings is not always appropriate for such measures. Option B methods (continuous monitoring) can often be implemented by using the EMCS to monitor itself, reducing M&V equipment expense. How savings from this measure are evaluated indicates the agency's commitment to quantifying savings.

Table 4. Project Motivation and M&V Rigor

Agency	EMCS Savings (% of total)	Total Annual Energy Savings	M&V Option	Dominant Motivation
NPS Yosemite	11	$34,206	A	Cost Reduction, Energy Savings
U.S. Coast Guard	16	$120,141	A	New Equipment
VAMC San Francisco	20	$209,000	A	New Equipment, O&M Savings
Navy - Pt. Mugu	28	$192,822	A with measurement	Energy Savings, New Equipment
U.S. Forest Service	35	$63,100	B&C	Energy Savings, Cost Reduction
DMDC – Monterey	52	$316,671	B → A	Energy Savings, Cost Reduction

Agencies have a strong influence over the rigor of their M&V plans because they pay for M&V services. Those with less interest in M&V are more willing to accept simpler approaches with greater uncertainties. Table shows that agencies interested in saving energy had more desire to track their actual savings (USFS and DMDC). Agencies seeking new equipment or cost savings (independent of energy savings) were less interested in tracking the savings and were more likely to accept an Option A approach (VAMC).

4.3 M&V Implementation Costs

Because the agency pays for M&V activities as a Service Phase expense, M&V cost has a strong influence on the final M&V option selected. Using information from the DO schedules (primarily H-3 and H-6), we estimated average annual M&V costs and compared them to the estimated annual energy cost savings. Included in the M&V cost was the service phase margin, which ranged from 18% to almost 30%. **Error! Reference source not found.** illustrates all of the expenses associated for each project as well as comparisons of M&V expenses to energy savings and project expenses.

We noted that there was no uniformity in developing costs for M&V activities among the surveyed projects. For example, some ESCOs included annual inspection activities in their maintenance budgets, other M&V budgets were developed with no descriptive task details at all. M&V activity costs were estimated on a time and materials basis and included all, not individual, measures. Thus, a large variation in the definition of M&V activities existed, and was reflected in the estimated annual budgets.

Generally, project capital costs increased with the number of measures; however, total M&V costs did not scale with the project capital cost or annual savings. Although evidence from discussions with agency staff indicated that M&V costs were reduced in order to reduce contract terms, the data showed no strong influence by the contract term on the M&V cost percentage of annual energy savings. The sample size was small, however, and there were many influencing variables on M&V costs. In order to isolate trends, a much larger sample would be required.

One way to assess whether M&V costs are appropriate is to compare M&V costs with the cost uncertainty of the project. This requires uncertainty and risk analysis in the planning phase. In general, projects with large uncertainties merit larger M&V budgets, enabling more rigorous and accurate M&V activity (this is discussed in more detail in the risk assessment section of this report).

From a cost perspective, Table 4 shows that annual M&V budgets ranged between 2% and 14% of the annual energy savings. A metric often cited in training courses[6] is that annual M&V costs, as a rule of thumb, should not exceed 10% of the annual energy cost savings. Table 2 shows that most of the project's ratios exceeded this value, but not by a large margin. It should be noted, though, that the M&V costs included the service phase margin. Still, these costs seemed relatively high given the prominence of Option A methods. Projects with smaller annual savings had a larger fraction of the savings dedicated to M&V services, presumably because there are some fixed costs associated with M&V services.

Of the seven surveyed sites, two (NPS and VA) had large cost savings that did not result from improved energy utilization, but rather from reduced O&M or electric rates. The savings were comparable to or greater than the cost savings from energy conservation. The M&V plans were not required to include verification activities for O&M or electric rate changes.

4.4 M&V Development Influences

It is difficult to generalize as to what point in the project development process the M&V discussions were initiated. Some projects were developed with a clear idea of how the M&V would be done from the beginning. In other projects, M&V was added on to the project late in the development process. The M&V plans for the seven projects varied from rigorous analysis and long-term metering to assumed values based on audit results. The level of rigor that we found in the M&V plans was not related to project capital cost or annual savings. The agency's commitment to measuring and verifying the savings seemed to be the common factor for having a good M&V plan.

M&V issues were never the most important issues during the negotiation phase. Negotiations between the agency and the ESCO primarily centered on what projects the agency wanted and what the ESCO could offer and still be economically viable. The criteria that most agencies established was a limited contract term (typically 10 to 15 years). Measures were selected or rejected based on whether the resulting combination of measures could be obtained within the specified contract term. Once a package of measures had been agreed upon (or nearly so), the costs of providing M&V services were then scrutinized. In some cases, M&V expenses were reduced so a specific contract term could be achieved. No measures were dropped because of M&V technical issues.

The FEMP support team evaluated the technical merit of the M&V plans for most of these projects. Some agencies did not actively participate in the development of their own M&V plans because they lacked either the expertise or the resources to do so, and instead relied heavily on the FEMP team. FEMP is now requiring agencies to pay for such support services, so in the future, agencies may be more self-reliant than those involved in this study. All the agencies had staff members who were aware of the FEMP M&V guidelines due to the DOE Super ESPC workshops.

Technical merit was rarely the reason for substantially changing an M&V plan. Although there was a good deal of negotiation during the development phase, most discussions sought to clarify or refine existing M&V plans. M&V methods were usually changed to reduce project cost and not because of technical concerns. In fact, many agencies were disappointed if an M&V plan had to use a less rigorous approach for cost reasons.

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[6] ASHRAE M&V Full-Day Course, California SPC Training Workshops

As previously mentioned, the agency's project motivation was the strongest factor in determining M&V rigor. Additionally, comfort with perceived risk was also an important consideration. Agencies that were confident that savings would materialize were less interested in pursuing rigorous M&V plans, especially if energy saving was not their primary motivator. Agencies motivated by energy savings were more willing to commit to more rigorous M&V plans as a way of tracking their savings, especially for non-lighting (and more risky) measures.

It was always the ESCO's role to develop the M&V plan for each site. All the ESCOs were familiar with the FEMP M&V Guideline, but they had various interpretations of the options. Combinations of options were sometimes used when a proposed method was not conveniently described as Option A or Option B. For example, VFDs at Yosemite fall under Option B in the M&V Guideline, but the agency changed over to Option A after one year. The plan called for continuous monitoring of the drives (an Option B long-term measurement approach); then, after one year, the savings were stipulated based on the first year's results (Option A). Similar combinations and descriptions were found at other sites.

The emphasis that ESCOs placed on some of the measurements may have been misdirected. For example, in lighting projects, most ESCOs measured fixture power instead of operating hours; however, it is usually the operating hours that are the most uncertain. Fixture power may be obtained from manufacturer specifications or from standard lighting tables with a high degree of reliability, whereas operating hours are a function of building use and occupant behavior. This caused operating hours to be the greatest contributor to savings uncertainty. One possible reason is that the emphasis on measuring fixture power comes directly from the FEMP M&V Guidelines, which emphasizes the use of Option A for lighting projects, both with and without measurements. The guideline itself is somewhat vague as to how to balance risk and rigor and offers little direction in deciding whether an Option A approach—with or without measurement—or an Option B approach is appropriate for a particular project.

A more probable reason for the emphasis on measured fixture power is risk allocation. An ESCO has more control over fixture performance than operating hours. Few ESCOs are willing to guarantee savings that are dependent on the agencies usage, which may vary over time and is more difficult to quantify. By measuring fixture powers and stipulating hours, the ESCO is guaranteeing the savings from parameters that they can control while shifting the usage risk to agency for parameters beyond the ESCOs control. In this sense, the risks are allocated appropriately to both parties.

5 M&V Plan Risk Assessment

5.1 General Discussion of Risk and its Control by M&V

All performance contracts entail some element of risk. In the realm of performance contracting, risk takes the form of uncertainty in the savings estimates and the possibility that savings may not materialize. For example, when an ESCO proposes a project estimated to save $100,000 in energy costs, the actual project may save between $80,000 and $120,000—the exact value will never be known. In extreme cases, there may be no savings at all. Agencies and facilitators must realize that they are *not* purchasing commodities that can be accurately characterized in terms of cost per unit (e.g., $/gallon), but are purchasing *the promise* that energy costs will decrease due to reduced consumption. The risk is that actual savings will fall short of this mark. M&V helps manage this risk and apportions it between the agency or the ESCO.

Common reasons why savings may not materialize are:

- *Design risk*—The original savings estimates were too optimistic.
- *Performance risk*—The new equipment may not be working properly.
- *Usage risk*—Equipment usage may be different than originally assumed.
- *Energy cost risk*—Dropping energy costs may reduce the value of energy savings.

5.1.1 Design Risk

Overly optimistic savings estimates can be a result of incorrect assumptions made during the engineering phase. For example, unrealistic efficiencies or load factors may have been used to estimate savings, or the actual operating strategy of a piece of equipment may be different than the assumed strategy. Verifying assumptions prior to project installation (i.e., during the Detailed Energy Survey) can reduce occurrences of this situation.

Baseline M&V activities, such as taking equipment measurements or performing short-term monitoring of existing equipment or human behavior reduce design risk by defining existing conditions. When an agency accepts an unverified value in the baseline estimates, the agency is taking on a certain amount of risk—and the baseline will not be available for verification after installation. Similarly, design-phase M&V activities may reduce risk for the ESCO by preventing over-estimates of savings and by catching design mistakes. Distribution of design risk between the ESCO and the agency depends on the situation and the M&V approach. Use of measured values in the design phase varied across the projects surveyed.

5.1.2 Performance Risk

Assuming improper equipment specifications, improper equipment installation or operation, or poor commissioning can also result in reduced savings. Identifying problems early can reduce performance risk. Monitoring equipment after installation can help identify performance problems, but inspections alone may not. For example, a variable-speed drive (VSD) on a fan has the capacity to save energy, but will not if the duct pressure transducer has failed. Monitoring the fan operation through the EMCS will reveal that the fan speed is not changing, but a walk-through inspection may not uncover this problem.

Using stipulated performance characteristics apportions risk to the agency. In general, savings based on nameplate data or engineering estimates will have more risk associated with them than those based on spot or short-term measurements. Even though these are "performance" contracts, stipulated performance characteristics were common in the projects surveyed.

5.1.3 Usage Risk

Equipment usage can also affect savings. Operating hours may be different than originally estimated, or they may change after a project is installed. For example, efficient lighting fixtures that are assumed to operate 2,000 hours per year would not generate the intended savings if they only operate 200 hours per year. Monitoring operating hours in a sample of spaces will verify that operating hours are similar to the assumed values, or alert the ESCO to changes if they are not. Changes in building use may affect operating hours, resulting in different savings values. If stipulated hours are not altered to reflect these changes, then the savings values will not reflect what is actually happening at a site.

Apportioning usage risk between the agency and the ESCO can be tricky. On one hand, usage directly affects savings, and improperly stipulated usage estimates by the ESCO could significantly overestimate an agency's actual energy savings. On the other hand, changes such as those in building occupancy are completely out of the ESCO's control, yet some M&V strategies may leave them responsible for disappearing savings.

5.1.4 Energy Price Risk

Another project risk is uncertainty in future energy prices. Contract terms ranged from 10 to 20 years, making certain prediction of energy prices impossible. The FEMP M&V Guideline offers little advice on this subject, so the ESCOs proposed what they felt was appropriate. Original energy price valuations included using the present energy cost for the length of the contract, escalating the energy prices to account for inflation, or using the real energy price each year during the contract term.

If energy valuations are based on future energy prices, then rising energy prices allow the ESCO to claim more financial savings for the same energy savings. Because savings are supposed to be tied to energy savings, not cost savings, this valuation method introduces energy fluctuations into the guaranteed savings amounts. If energy prices were high but energy savings goals were not met, it would allow the ESCO to meet the guaranteed savings amounts when in fact they had not. Conversely, declining energy prices are a risk to the ESCO, who would not be able to claim that savings goals had been met even if they had. Using uncertain dollar values to represent energy savings presents a risk to both the agency and the ESCO.

Using fixed energy prices during the contract term protects both the agency and the ESCO from price uncertainties. If energy prices rise, the agency would still pay an increased utility bill, but not as much as it would have in the absence of a Super ESPC project. If energy prices fall, the ESCO is protected from not meeting savings guarantees while the agency pays less regardless. Using constant energy-cost values provides a fixed relationship between energy savings and financial savings and minimizes risk to all parties.

An alternative is to escalate energy prices to account for inflation. Although no one can predict what energy prices will do in the long term, inflation rates of 2%–3% are commonly used to estimate savings. (These values are justified by Energy Information Administration predictions.) One effect that inflating energy prices has is that the guaranteed savings will increase during the contract term. This allows the ESCO to charge more for the project in later years without violating the directive that the agency can never pay more than the guaranteed savings amount. This does present a small risk to the agency, which must ensure that its energy and O&M budget increase by the estimated inflation rate regardless of actual inflation rates.

5.1.5 Value of Guarantees

While Super ESPC projects have guaranteed savings, these guarantees are only as good as the methods used to verify the savings. In principle, guaranteed savings transfer all project risk to the ESCO. In practice, failure to verify that savings are as claimed transfers the project risk back onto the agency even if they are 'guaranteed.' Performing *at least some* post-installation M&V is the only reliable way of knowing whether actual savings are meeting the guaranteed amounts. This is why the Super ESPC requires ESCOs to exert some M&V effort to show that the savings are real and greater than the guaranteed amounts if the guarantees are to have any value.

5.2 Perceived Risks and M&V

Most agencies are aware of project risks and realize that savings values are estimates, and that actual savings will be different and may fluctuate due to external factors. They are also aware that in rare cases no savings will materialize. Most are confident that the claimed savings estimates are reliable and conservative, but still want some assurance that the savings are being realized. In some cases, agency staff accepted somewhat less M&V assurance than they would have liked to see in the interest of making the project work.

5.3 Risks in M&V Options

The purpose of M&V is to reduce the total risk and to apportion the balance of the risk among the two parties. By verifying that savings are materializing as intended, the agency's risk of overpayment is reduced. Verification assigns the project risk to the ESCO, who is responsible for ensuring that installed measures are working properly and savings are being generated.

Total project risk is related to both total savings and uncertainty. Both components should be considered when determining project risk so appropriate M&V efforts can be made. For example, a small lighting project with well-defined operating hours will have a much smaller financial risk than a large HVAC project where savings are not as well defined (see Table 5).

Table 2. Financial Risks Due to Savings Uncertainty

Sample Project	Guaranteed Savings	Savings Uncertainty	Savings Risk
Small lighting	$50,000	10%	$5,000
Large HVAC	$500,000	20%	$100,000

In this example, an agency is at far greater financial risk from the HVAC project than the lighting project, both in absolute and relative terms. The HVAC project may save between $400,000 and $600,000 dollars, but if the savings are *below* the guaranteed amount, then the agency is at risk of paying greater than anticipated energy costs. The purpose of M&V is to reduce financial risk to acceptable levels by reducing uncertainty. In the above scenario, most of the M&V effort should be concentrated on the HVAC project to reduce the agency's total risk.

Reducing uncertainty and risk with M&V activities, however, increases project cost. Good M&V activities reduce uncertainty without significantly increasing project costs. In the example above, reducing the HVAC uncertainty from 20% to 10% will reduce the project uncertainty by $50,000, which reduces the maximum possible overpayment from $100,000 to $50,000.

The different options described in the FEMP M&V Guideline have different implementation costs and levels of rigor. Option A (stipulated savings) has the lowest M&V cost but the greatest uncertainty. Option B (end-use monitoring) is considerably more accurate but has a higher implementation cost. Option C (whole building analysis) can be implemented with varying degrees of certainty and cost. Computer simulation (FEMP Option C, IPMVP Option D) is labor- and cost-intensive but can provide a high degree of certainty. It is most often used for new construction projects where real baseline data does not exist.

Option A is used when estimating the savings of a particular measure. It calls for stipulating the savings at agreed-upon values for the contract duration. These values are to be determined based on spot and short-term measurements of old and new equipment. Costs are minimized by not repeating these measurements every year. Risk is reduced by conducting annual inspections to see that the installed equipment is still present and functioning as intended. Because the use of measurements is limited with this option, it is most applicable to constant-load measures that are unlikely to significantly change performance over the contract term.

Option B is also used when estimating the savings of individual measures. It is more rigorous and more expensive than Option A because continuous equipment monitoring is performed for the contract duration. Continuous monitoring reduces the uncertainty in the savings estimate and reduces long-term risk. This option is more applicable to variable-load measures because of their greater complexity, or to measures that may change performance due to weather or occupancy patterns, or both.

Option C, both regression analysis and computer simulation, considers only the total building energy consumption and does not provide savings estimates for individual measures. It should be used only in cases where the retrofits will cause a substantial decrease in energy consumption. When implemented rigorously, this method can estimate the savings due to a large number of interrelated measures if the total savings are large enough. Uncertainty and risk are reduced because weather and occupancy factors can be considered when estimating savings. In some cases, M&V cost may be less than those associated with performing a large number of Option B measurements and calculations. Risk is reduced because actual building energy consumption is used to estimate savings, which provides ongoing reassurance that the savings will persist.

5.4 Discussion of Risks in Surveyed Projects

5.4.1 Stipulation Risk

By far, the greatest risk the surveyed agencies are exposed to is that associated with stipulated savings. Most Option A methods for stipulating savings base the savings estimates on pre-and post-retrofit equipment measurements. These measured values then determine the savings for the contract duration.

While this method has the lowest cost, it also has the highest risk because actual performance is not verified throughout the contract duration. Persistence is usually addressed by conducting annual inspections to verify that equipment is installed and has the *potential* to save energy, but whether the equipment is *actually* saving energy is rarely verified directly.

Steps taken to minimize uncertainty may not be as effective as desired. While taking equipment performance measurements is intended to reduce uncertainty, some parameters have a greater affect on the resulting uncertainty than others. For example, lighting savings are a function of the power difference between the old fixtures and the new *and* the number of operating hours per year. Fixture powers are often known with relative certainty even without measurement (a 100-watt (W) lamp usually draws about 100 W). Operating hours, however, are known with significantly less certainty. While surveys of a facility and interviews with staff can identify occupied hours, occupancy does not always translate into operating hours. Experience with utility demand-side management (DSM) programs shows that operating hours may be significantly different (2x or more) than originally assumed due to the presence of cleaning crews, sporadic occupancy, or sufficient daylighting.

Measuring fixture power reduces the already small uncertainty in that parameter but does nothing to address the large uncertainty in operating hours. Stipulating the operating hours without measuring a sample places the agency at risk of unrealized savings if the actual operating hours are significantly less than the assumed and stipulated values. (There is little risk to either party if hours exceed the assumed values). ESCOs attempt to minimize risk to the agency by developing conservative estimates, but only two of the surveyed ESCOs performed any operating-hour measurements.

5.4.2 Performance Risk

Equipment that fails to perform as intended can also result in unrealized savings and place either the agency or the ESCO at risk. An example might be a VSD installed on a fan motor. While this retrofit has the potential to save energy, it may not perform as intended because the air handler is undersized and the fan needs to operate continuously at full speed or because a defective pressure sensor fails to correctly modulate the fan speed. In the first case, sufficient pre-installation measurements would have revealed that the air handler was undersized and that a VSD was not the appropriate retrofit. Because the ESCO has guaranteed the savings from this project, the agency is protected from risk, but the ESCO must either make additional changes at its expense or alter the payment schedule to make good on the guarantee. In the second case, the pressure sensor can be fixed and the system restored to intended operation so savings are again realized.

In both cases, sufficient M&V must be performed both before and after the installation to verify that savings are being realized. In the event that savings are not materializing, the ESCO has sufficient information to identify the cause and take corrective action. If savings are stipulated, this information would not be available to the ESCO or the agency, and the situation would not be discovered. This makes the guaranteed savings less valuable, because without adequate M&V, there is no way to enforce them.

5.4.3 Usage Risk

Usage risk occurs if an agency decides to change operating schedules or usage of a building. Referring back to the lighting example, changes in building schedules or use may affect lighting operating hours without the ESCO noticing. Decreased operating hours will erode savings (or savings will be falsely attributed to lighting) if stipulated hours are not changed to reflect actual usage. Annual inspections will show that the installed lighting fixtures have the *potential* to save energy, but this potential is not being realized if the lights are not operating as assumed.

Stipulated savings estimates that are not based on actual measurements or that are not updated to reflect changes place the risk back on the agency despite the guaranteed savings. Without adequate feedback, the ESCO cannot amend the savings estimates.

6 Recommendations

The agencies, DOE, and our staff identified several recommendations for improving the planning and implementation of M&V. The recommendations are in three broad categories: M&V resource improvements, M&V plan and budget standardization, and establishing a framework for review and assessment of M&V plans in the development phase.

6.1 Improve M&V Resources

M&V resources exist that are intended to provide guidance for developing and implementing M&V plans. Chief among these are the FEMP M&V Guideline and other FEMP produced materials. Review of the existing plans illustrates weaknesses and ambiguities in existing resource materials. There was much variation in the content of each M&V plan evaluated as part of our assessment, even for similar ECMs. It was clear that the current guideline provided insufficient direction on how to develop an M&V plan or what the characteristics are of a good M&V plan[7]. After review of seven M&V plans, several recommendations for improvement to the guideline are made:

1. *Clarify option definitions and other terms.* There is much apparent confusion about how and when the options are to be implemented, particularly Option A. One agency staff member reported that she had to read the guideline a number of times before understanding the distinctions between the options. It is recommended that the guideline further emphasize the definitions of the options and their intended use, and more clearly indicate each option's expected activities.

2. *Distinguish between equipment performance (e.g., efficiency, capacity ratings) and equipment usage (e.g., operating hours, annual energy consumption) and their relationship to savings.* These are distinctly different, but are parameters required to quantify savings. Clearly define these parameters in the guideline, so that ESCOs and agencies know these factors must be measured or otherwise quantified for each ECM in their projects. Provide guidance on which parameter is more relevant to determining savings. The M&V plans reviewed placed too much emphasis on performance (lighting power, motor efficiency) and not enough on usage (operating hours).

3. *Provide recommendation as to which M&V options and methods should be used with different types of measures, based on project technologies, risks, and value.* The FEMP Guideline provides little advice on how to balance costs and risks when selecting an M&V plan.

4. *Reduce the volume of the FEMP M&V Guideline's text and perhaps prepare different versions for federal management versus federal and ESCO technical staff* by eliminating redundant text in individual M&V methods. Some agency staff reported that the guideline is too long, repetitive, and unclear in many areas. A shorter version might also be appropriate for agency managers that need to simply understand the basics of M&V requirements and options.

[7] These comments are based on the current FEMP M&V Guideline, published in 1996. A newer version, developed at the end of 1998, and now available for public comment, incorporates some, but not all, of these recommendations.

5. *Clarify the use of stipulations for Option A*. Specify when equipment performance parameters or equipment usage parameters may be stipulated under Option A. Only in rare (and well-supported) cases may energy savings values also be stipulated. Define acceptable sources of data, and the context for their use, upon which stipulations may be based. Data sources may include spot or short-term measurements, previous studies, maintenance logs, and control schedules. State examples of unacceptable sources of data, such as handshake agreements, unchecked assumptions, past experience, etc. State that periodic (i.e., at least annual) verification activities (which may include actual measurements) are required with Option A methods.

6. *Develop M&V requirements for operations and maintenance (O&M) measures.* One of the surveyed projects had annual O&M savings that exceeded the annual energy savings of all energy conservation measures. Other projects' O&M savings were the second or third largest cost savings of the project. Payments on O&M savings were not subject to any formal M&V scrutiny, which can be a source of considerable risk to an agency. Part of the reason for this is the simplicity of certain O&M savings, but another part of the reason is that there are no established M&V guidelines for O&M.

7. *Provide additional training on M&V and develop in-house FEMP M&V expertise.* Training can be useful for agency staff, ESCO staff, and for developing additional FEMP in-house expertise. Additional expertise can be used to provide M&V-specific support to agency staff and project facilitators.

6.2 M&V Plan and Budget Standardization

The FEMP M&V Guideline provides a great deal of flexibility, which can be both a strength and a weakness. The strength is that M&V plans can be tailored to meet specific applications and requirements. The weakness is that there is no standardization, and some of the plans reviewed were missing key elements. There is also little agreement on how to determine the cost of M&V services. Some specific recommendations include:

1. *Require that M&V costs be estimated for each individual measure or group of measures.* This provides the agency with an idea of what it gets for the money spent. The costs should be developed at the beginning of the negotiations, so that all relevant costs are available during negotiations. Analysis should consider the cost of M&V relative to the level of uncertainty the M&V provides and, thus, the value of M&V versus the certainty in cost savings it provides.

2. *Integrate the discussion of M&V with the selection of ECMs when finalizing DOs.* Rather than discussing M&V last in the process, as was the usual case in the projects surveyed, start the discussion earlier. Preferably, M&V should be part of the measure design process and M&V budgets should be included in all preliminary estimates. Certainly the M&V should be established prior to the time contract budgets and terms are finalized.

3. *Develop a standard framework for M&V plan content and evaluation.* No formal evaluation guidelines or required M&V plan elements exist to help ESCOs prepare and agencies review M&V plans. One option that has been discussed is a checklist for what should be in an M&V plan. Section 6.3 describes some possible evaluation framework contents.

4. *Provide information on requirements associated with meeting federal ESPC regulations.* In addition to M&V plan content and evaluation criteria, a description of what is required to comply with federal ESPC regulations would be useful.

5. *Develop sample M&V plans and reports*. Sample M&V plans and reports will provide both agencies and ESCOs examples to follow when preparing to submit documents. Providing a description of legal requirements will also assist in plan development and evaluation.

6.3 M&V Plan Evaluation Framework

Specific items in an M&V plan might include the following elements:

Project Overview

I. Project- and measure-specific approach (including FEMP option type)
   A. Measure description and how it will generate savings
   B. Describe what savings will be quantified and claimed
   C. Describe any interactive effects
   D. Briefly describe measure risks and/or areas of uncertainty
II. Baseline equipment definition
   A. Document existing equipment and space conditions (lumens, temperature)
   B. Describe supporting measurements (from Detailed Energy Survey)
   C. Describe assumptions, stipulations, and source of supporting information
   D. Describe how baseline adjustments will be implemented
III. Post-installation equipment definition
   A. Document new equipment and space conditions (lumens, temperature)
   B. Describe supporting measurements (to be made)
   C. Describe assumptions, stipulations, and source of supporting information
IV. Energy Savings Calculation
   A. Describe intended precision and confidence levels
   B. Describe defining equations
   C. Describe required variables
   D. Describe source of data (measurements, assumptions)
   E. Describe how data is measured or modeled (including computer programs used)
V. Measurement equipment specifications
   A. Provide equipment descriptions
   B. Provide sampling plans and sampling criteria
   C. Provide measurement schedule and duration
   D. Provide accuracy specifications
   E. Describe calibration interval
   F. Detail raw data reporting format (especially computer files)
   G. Provide identification of responsible individual or organization
VI. Annual activities
   A. Describe inspection/verification activities
   B. Describe measurement and analysis activities
   C. Detail reporting requirements
   D. Provide identification of responsible individuals or organization
   E. Describe quality assurance plan

VII. Report sample format

- A. Describe data presentation format
- B. Detail reporting frequency
- C. Describe savings true-up reporting
- D. Detail baseline adjustments

VIII. Estimated M&V costs by measure and activity

As part of the framework, there should be guidance for evaluating M&V plans in terms of cost and risk. A simple table that lists and ranks the ECMs by their estimated energy cost savings, associated M&V costs, and risk of realizing savings could be constructed. The risks may be qualitative, and based on the uncertainty of the energy savings estimation. The table could be used to determine whether M&V resources are appropriately applied.

Appendix A: Questions for Agency and ESCO Staff Members

1. Why did your agency pursue a delivery order (DO) for these ECMs?
   - ❑ Energy savings
   - ❑ Equipment upgrades
   - ❑ Performance improvement
   - ❑ EPACT compliance
   - ❑ Other

   Which of the above were most important? Why?

2. Were there other contract means available? (Such as area-wide agreements or direct funding.)

3. Was the DO process using Super ESPC the most appealing option? Why or why not?
   - If so, was the idea of getting verified energy savings important or unimportant? Why?
   - Were there other appealing aspects of the DO process?
   - If not, what aspects were unappealing or difficult?

4. Did you have competing ESCOs bid to do the work on your facilities?

5. Who identified the ECMs—the agency or the ESCO?

6. Were you familiar with the FEMP M&V Guidelines before starting the DO process?

7. Did the guidelines provide a clear description of what M&V is, and what the necessary steps are in developing, implementing and reporting M&V activities?

8. Did you find them helpful in understanding and reviewing the ESCO's submitted M&V plans?

9. Did you rely on 'experts' to advise you as to whether a particular version of the M&V plan was appropriate or not?

10. Was the FEMP support team helpful in evaluating plans, providing advice, or assisting in negotiations?

11. What M&V Options did you select for each measure? Why?

12. How well did agency staff understand the M&V plans? (assumptions and implications)

13. During the negotiation process for the DO, when did you first start discussing M&V?

14. Who developed the M&V plans for the implemented measures?

15. Was discussion and negotiation of the M&V plans a difficult or an easy process? Why?
    - Little understanding or poor communication of M&V on ESCO's part?
    - Allocating risk between the agency and the ESCO?
    - Cost or difficulty of M&V?
    - Other?

16. How was project risk allocated between the ESCO and the agency?

17. Did you get what you wanted in terms of M&V for each ECM from the negotiation process?

18. How effective has the implemented M&V been to date?

19. What other issues during DO negotiations were important? How did M&V compare to them?

20. Were O&M issues included in M&V plans, or were they separate?

21. How confident are you in the O&M provisions?

22. What provisions were made for baseline adjustment or future changes to the facility?

Appendix B: Site Reports

1 SITE 1: YOSEMITE NATIONAL PARK, CA

Site Contact:	Diane Mansker
Contact Date:	October 29, 1999, via conference call
Schiller Contacts:	David Jump and Ben Gallant
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

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 Super ESPC, and DOE contracting assistance and technical review freely available, a Super ESPC contract seemed by far the simplest means of achieving these goals. Also, on a grander scale, the NPS was interested in test-driving the Super ESPC, 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 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 40 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 DO. No O&M savings were claimed, but the voltage upgrade savings are based purely on rate structure changes 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 variable air volume (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 discussed from the very beginning of this project because of 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 DOE to install continuous kW metering on two of the proposed ECMs—the VAV conversion and VFDs at the wastewater treatment plant. Because the NPS was performing the metering, we 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 the assumptions was especially important, because stipulations based on these assumptions will determine the savings for the rest of the contract. For example, the lighting savings calculation uses operating hours based on staff interviews, an assumption that experience shows to have a certain amount of uncertainty associated with it.

We used a DOE2.1E computer simulation 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

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

"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, time constraints and resources limited the opportunity to do this. In the end, other DO issues, such as contract term 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 more than 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 to agree 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. The following is a more detailed explanation of the M&V approaches.

1.4.1 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. Because 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 with 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.

1.4.2 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 the 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. We used TMY weather data from California Climate Zone 16. Most parameters are estimated or assumed without measurement, including the percentage of 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.

1.4.3 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 will be provided to the 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, although 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.

1.4.4 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 the 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.

1.4.5 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 2,600 annual hours. Thus, a no-measurement approach seems like an appropriate low-cost application of the FEMP Guideline’s LE-A-01 method.

1.4.6 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 Wastewater Treatment Plant with high-efficiency motors and VFDs. The pumps currently operate continuously, but after retrofit the VFDs will adjust aeration based on input from dissolved oxygen sensors in the wastewater 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; elsewhere in the M&V plans most values are estimated or assumed. Metering the higher savings load reduces uncertainty and is a good application of M&V effort. It is important to remember that this approach would not have been possible without DOE funding for measurement equipment.

These two “Option B” measures change over to stipulated savings after one year of measurement. Thus, the risk for future performance is transferred back to the park, protecting BMP from usage changes that could diminish savings; however, it does somewhat degrade the “performance” aspects of the contract. For the VFDs at the wastewater treatment plant this may be appropriate. Assuming that 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. Because 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. Because 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 although the discrepancies between the simulated consumption and the actual consumption average 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 Super ESPC 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 its cost, 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:	October 6, 1999
Schiller Representatives:	Ben Gallant and Mark Stetz
Documents Reviewed:	Initial M&V plans, Final, Final H schedules

2.1 Project Motivation

Shortly after the DOE awarded Johnson Controls International (JCI) one of the Super ESPC 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 JCI 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 and 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 its 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 list 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 Super ESPC 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 the labor-cost reduction associated with the boiler plant; the second largest savings are from lighting measures.

Table 1: VAMC Super ESPC 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 that 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 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 changes 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 8,760 hours per year or are controlled by timeclocks.

Thus, savings M&V 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 its M&V plans, several of which did not clearly fit into FEMP Guidelines classifications, or exactly follow the guidelines' methods. For example, the M&V plan for the motor 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 motor projects. 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 a 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 its 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 would probably 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 its 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. The efficiency of the existing boilers was measured at 76%. The new system is guaranteed by the manufacturer to have and maintain an efficiency of 80%. JCI 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, and 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 the reconditioning of air-handler dampers. In addition, the Life-Safety Supervisory System (fire alarms) will be replaced. There are no energy savings associated with this last improvement, but it was important to the VA to replace this system, and we grouped it with the 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. Because 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 more than 15 years can be reliably approximated using this method. As 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 were 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.

Because of the salt air at this location, some of the cooling coils were corroded and clogged, reducing airflow and significantly increasing fan energy consumption. By replacing the existing coils with new ones, pressure drop and fan energy were significantly reduced. A combination of Option A and B M&V approaches 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 that need attention. Fan motor demand and airflow rates will be measured annually to verify persistence. Savings are dependent on the airflow through the coil, so significant changes to the airflow will require adjustments to the baseline and savings levels. In the absence of any airflow changes, the 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 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 timeclock or the EMCS and therefore have known operating hours. An Option A/B method was implemented

36 Which would require monitoring pressure drop.

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 O&M 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. JCI started with the present energy prices in 1998 and will escalate these prices by 3% per year according to 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 contradicts current thinking regarding 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 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. Because 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: the lighting and controls upgrades. 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 have been reduced without an increase in M&V cost or a change in M&V Option is lighting. Lighting projects typically are low-risk, and it is often helpful to verify the operating hours through short-term metering. Many of the fixtures are stipulated to operate nine hours per day. If a sufficient number of fixtures operate for less time, 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

M&V does not appear to have been a primary concern in the VAMC DO 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, because the majority of the savings was in O&M costs, energy savings M&V took on 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: FORESTSERVICE LABORATORY, CORVALLIS, OR

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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 USFS Laboratory provides laboratory and office space to researchers at Oregon State University. The USFS subleases 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 its expenses so that its 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 its utility provider, PacifiCorp. Initial legal advice discouraged the USFS from using PacifiCorp's energy services because of the lack of guaranteed savings. In 1997, Honeywell was selected as a Super ESPC 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 a 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. Super ESPC 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 O&M 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

The 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 outside air 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 had 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 that were then reviewed by the FEMP support team (primarily Mike Holda and Steve Kromer), who reviewed and suggested changes. The USFS preferred that FEMP representatives actively support the 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. M&V 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 O&M 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 a 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 proceed. 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 and the laboratory MUA unit and installed a new computerized operator interface. The new control system will produce savings by decreasing the use of specific air handlers, night setback, and by reducing the 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 and 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 to inspect for or replace 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 the 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 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/month 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 based on 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 and cooling energy consumption. In the event of a mild winter (heating degree days [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 cooling degree days [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 the 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 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 pipes. 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 domestic hot water (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 the 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 would place the USFS at risk. Because Super ESPC savings are tied to energy rather than financial savings, this strategy was deemed inappropriate. In response to comments from the FEMP reviewers, Honeywell revised its 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

M&V 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 its utility bills to validate the savings estimates, and has verified savings from the lighting and controls project. USFS will be monitoring its steam consumption this winter to validate the steam savings. At 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 the new control system. It was willing to pay more (by extending the contract term) to obtain a system that would provide more control in order to obtain more savings. It also wanted to upgrade the quality of the lights and use full-spectrum bulbs instead of the typical cool white bulbs originally proposed. The USFS was happy to obtain better lights, an improved control system, and steam system upgrades without requiring capital funds to do so, and was especially pleased to obtain these things in a package where it 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

In June 1997, FEMP released an initial RFP for the Western Region Super ESPC. The RFP included requests for proposals for several project sites, including the FAA's Air Route Traffic Control Center (ARTCC)[2]. The FAA site was invited by FEMP to take part in this solicitation as part of the initial Super ESPC projects. The FAA had previously expressed an interest in complying with EPACT mandates and reducing energy costs. The Super ESPC 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 Super ESPC service providers for the Western Region. To implement these initial Super ESPC projects in a timely fashion, a separate provider was chosen for each site. The FAA reportedly had second pick, and selected Johnson Controls, International, based on its proposal. The DO for this project was signed in July 1998 and was the first one issued in the Western Region under the Super ESPC program.

4.2 Project Description

The FAA's 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 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.

JCI was limited to a brief walkthrough of the FAA facility prior to submitting its original proposal. The original proposal included recommendations for: lighting retrofits; lighting controls; energy efficient motor replacements; VFDs for fans, pumps, and chillers; air system reconfiguration; and automated control system expansion. Once JCI was selected, a detailed site energy study, feasibility study, and cost analysis were conducted. The final implemented ECMs included a comprehensive lighting retrofit, occupancy sensors for office lighting, and VFDs for central plant pumping.

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

Table 3: Super ESPC 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

JCI 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, light-emitting diode (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 high-efficiency ones. Occupancy sensors were installed in some private offices and conference rooms for lighting control in those areas.

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

The M&V option used for these lighting measures was stated in the DO as 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. VSDs were installed on each of these three pumps through the Super ESPC project. The desired flow rates are now achieved by reducing the pump speed, which allows the manual control 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 VFD was installed to serve any one of the three pumps, which alternate operation. The desired flow rates are now achieved through reducing the pump speed, allowing the manual control valves to remain open. Control points for the new VFDs were added to the existing Metasys digital control system.

4.3 Use of M&V Guidelines

The contract administrator on this project attended a Super ESPC training session. Because this project was one of the first to be implemented, the FEMP M&V Guidelines had not yet been published when the project began. The FAA staff did receive a copy of the guidelines later in the DO 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 because both the condenser and chilled water pumps are known to operate primarily in a single steady-state mode, with two chilled-water pumps occasionally operating simultaneously. 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 the 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.

FAS staff has not yet verified the correlation between the speed of the pumps and the energy used. Because JCI 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

JCI 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 chosen for the pumping VFDs was VSD-A-01, which was changed to VFD-B-01 in the DO. The lighting methodology did not change.

Although some FAA staff attended a FEMP Super ESPC 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 DO with JCI. Steve Kromer and Cheri Sayer of FEMP provided guidance on all aspects of the monitoring and verification plan. The FAA staff worked with JCI to determine occupancy hours for 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 DO provides for adjusting the operating baseline for the project annually if required because of 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; and, at the same time, revising the operating baseline 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 JCI, 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. Because of 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 the 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
- 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.

JCI 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

JCI 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 operating hours of the central plant change, or were not defined properly. JCI 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 because power use does not vary linearly with speed. The Metasys control system has sufficient capability to accumulate more accurate data.

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

4.6 Other Comments

The DO and contracting process took about 18 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 Super ESPC program. Only the contracting officer from this facility attended a FEMP training session. It may have been helpful to have additional training materials to give to the involved parties.

The original JCI proposal to the FAA was for a 25-year contract. Some of the staff at the FAA were uncomfortable with the extended term of the contract. Eventually, the project settled on a 15-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. DO 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, there were so many people from the FAA involved in the decision-making process, that progress 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 Super ESPC process for the FAA was budgeting impacts. Budgeting had to account for the payments made to JCI and a future reduction in the operating budget once the DO is completed. The requirement of sharing 50% of all savings 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:	October 14, 1999
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 the DMDC moved in, the facility systems were not updated for the new occupancy, which was primarily 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, the 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. The DMDC has since hired a full-time facility engineer (the DO process began prior to the hiring). In addition, major renovations are scheduled to begin in 2000 by MilCon[3], and construction will be completed in two years.

The 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 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.
- FEMP Super ESPC.

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

- It avoided going through the IDIQ process since DOE had already completed it.
- 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 was available.
- The FEMP process provided flexibility, although contracting procedures must be followed.

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

For the other options, staff from the DMDC would need to be actively involved in describing what was needed, developing the projects, and writing the RFPs. As previously noted, the DMDC did not have enough 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 Super ESPC process included:

- The 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 the contract term. The DMDC reported that it 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 the Ft. Ord Army base. The base was decommissioned in 1995 and the DMDC took possession in 1996. The facility is a 25-year-old, eight-floor building totaling 367,000 square feet. The DMDC moved in without any major reconstruction or changes to lighting and HVAC equipment.

Three organizations occupy the building, accounting for approximately 600 people. A military construction (MilCon) project is planned to take place two years after the completion of the Super ESPC project, and will increase the building occupancy to 1,300 people.

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

The final measures included in the Super ESPC project were: boiler plant upgrade; 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.

The 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.

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

Table 4: Super ESPC 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 DDC 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, and hot-water 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.

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. VFDs will be installed on some air handlers and exhaust fans so they can operate at reduced capacity. Existing mixing boxes will be converted to VAV operation, and unneeded HEPA filters will be removed. Ventilation and air conditioning to unoccupied spaces will be discontinued.

Savings will be realized 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 fluorescent 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 reconfiguring 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 the DMDC was completed in March 1998. DMDC released the DO 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.

The DMDC had no engineering staff to assist in negotiating M&V. They relied heavily on DOE staff and the Corps of Engineers. Deneen Seril, the DMDC Super ESPC 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.

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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) of 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.

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 15-year contract. The final DO is for nine years, after major changes in requirements since the RFP. The 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
- 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
- Evaluating impacts of the MilCon on the Super ESPC project.

Sempra indicated that they perceived only one real risk, which was how well the DMDC would maintain the equipment. The 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 about risk centered on properly determining the interactive savings between the ECMs—adjusting the baseline used in each calculation so savings are not double counted. For example, the impact of boiler and ventilation changes—the boiler will be used less after 100% OA ventilation is reduced—what are the 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 the DMDC took over the building.

The MilCon project affects the M&V plans for the Super ESPC 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 that specify how savings shortfalls will be addressed, should they occur.

An incentive from PG&E's 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.

Because 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 should be categorized as 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 seven 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 are 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 the on-off scheduling of equipment, as well as the 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 usage by 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 VFDs and EMCS are properly controlling the fans, 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 by reducing the pumping power on the hot-water system with 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 (they may be included in other sections of the DO). The variables used to determine the baseline and post-installation energy use are identified, as are the source of the 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 two years after project is implemented. The MilCon project would diminish savings due to increased occupancy. After two 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 that are the most uncertain to quantify tend to be the subject of measurements in the post-installation period. Table 6 shows the variables that will be measured for each ECM.

Table 6. Measured variables for top three ECMs.

ECM	Baseline	Post-Installation
Boiler Efficiency Boiler Auxiliary Equipment	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 (constant load)	Motor kW, Op. Hrs. by scenario

During the baseline period, the operating 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

The DMDC and Sempra offered some suggestions to improve the M&V negotiation process. Both indicated that the M&V discussions were long and intensive and desired to reduce 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 will be selected based on individual ECMs. It is important for the 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 clearer recommendations would be helpful. It was also noted that the FEMP workshops helped quite a bit.

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6 SITE 6: COAST GUARD ALAMEDA

Site Contact:	Lt. Dennis Evans Facilities Design and Construction Center Pacific (FDCCPAC) U.S. Coast Guard
Teleconference Date:	October 13, 1999
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, U.S. Coast Guard “Lessons Learned” Paper September 20, 1999.

6.1 Project Motivation

The United States Coast Guard (USCG) had been considering entering an ESPC for six years. Its motivation was to reduce energy use by 20% from the 1995 level by 2005. The Coast Guard Academy in Connecticut had been trying to enter an ESPC since 1992 (when they were called Shared Energy Savings). USCG 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, and the Coast Guard instituted an energy program. The program was centered at the 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, Virginia. On the West Coast, the energy program was centered at the FDCCPAC in Seattle, Washington. In 1996, the DOE program manager visited the CG facilities energy program to explain the Super ESPC concept, and the energy manager volunteered pilot sites at various USCG sites. The first ESPC was at the Academy, using the Army IDIQ. Thereafter, the Kodiak and Alameda projects were developed under the Super ESPC IDIQ.

Shortly after the IDIQs were awarded for the western region, the Coast Guard began developing the RFP for Alameda. Initially, the Coast Guard wanted one ESCO and a single ESPC for its 18 largest sites on the West Coast. Motivations for the projects differed; while USCG station personnel had a 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 was necessary. FDCCPAC focused on getting this project started.

The energy management team at FDCCPAC wanted to pursue Super ESPC projects and saw advantages to their use:

- An opportunity to acquire new equipment with little up-front funding.
- The contractor would take on the performance risk of the project, which allowed the 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 there will be 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 USCG 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 USCG sites. Honeywell identified initial ECMs in Alameda, San Pedro, Seattle, and Honolulu, and approached the Coast Guard in 1997. After USCG review, it was determined that Alameda was the best candidate for an the first Honeywell Super ESPC DO with the Coast Guard. In April 1998, the initial proposal was received, and negotiations on finalizing it began. The DO was signed in April 1999.

6.2 Project Description

The CG 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 six-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 the Coast Guard did not want to enter a contract for longer than ten years.

Honeywell originally proposed a broad range of measures at the 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.

summarizes the ECMs, their costs and expected annual savings, and the M&V options used. Savings reported include O&M savings, and were obtained from the final DO H-schedules. The M&V cost shown is the entire cost, including the service phase margin, for the ten-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 Super ESPC 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 a lighting upgrade.

6.2.1 Energy Management and Control System

This was a measure specifically requested by Alameda staff. A DDC EMCS was installed to automatically control the boilers, hot water pumps, and AHUs in 11 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, and calibration of sensors. Honeywell will also provide training and operations manuals to the 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 LEDs.

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

Shortly after completion of the detailed energy survey, Honeywell provided the initial M&V plan, dated October 1998. It included all of the originally proposed ECMs. From the start of discussions to finalization of the DO, 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 the engineering staff from the Seattle office attended a two-day FEMP training on M&V before starting the DOs, and thus had a good understanding of the FEMP Guidelines, the 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 an 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.

The reasons cited for the Option A M&V methods were the lower cost and the 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 because, in theory, the EMCS could have been used for measurements. However, the energy savings generated from the EMCS were 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—Coast Guard 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 that made up the annual contractor payments. It indicated an 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 (ten years). 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. 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, and 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, 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 are 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 to 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 used to determine 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.

The 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 DO, 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 would 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.

General Comments on M&V Plan

The description of M&V activities was 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 USCG staff indicated that a 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 the 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 increase the value of the energy savings, resulting in gains for the Coast Guard, and conversely, decreases in energy rates reduce 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 to calculate 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, the 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. Operating hour estimates are the primary source of savings uncertainty and risk in lighting projects because they are hard to estimate in most cases. One way to reduce uncertainty in operating hour estimates is to focus measurement activities on operating hours rather than on fixture wattages. This can usually be justified in larger projects.

Because operating hours are a parameter that the ESCO does not typically control, a more common method is to review and agree upon the operating hours, which is the method employed here. This method shifts the risk to the Coast Guard. At the Alameda Island facilities, which operate on regular schedules, estimates can be made with sufficient accuracy. This is typically not true for residential facilities, at least in tenant apartments. Estimates of operating 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 made 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. 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 or efficiency) and usage (load factor or operating hours) 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, using 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.

M&V 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 compared to the predicted energy savings. Small M&V budgets limit the M&V activities that can be performed.

6.6 Other Comments

The Coast Guard and Honeywell did try to limit M&V costs because project savings were small. Lt. Evans said that, as the 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 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:	November 2, 1999
Schiller Representatives:	Lia Webster and David Jump
Documents Reviewed:	M&V plans: Initial (December 21, 1998) Final (June 18, 1999), 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 Super ESPC project.

Using the Super ESPC program was an idea that originated from the Naval headquarters office in Washington D.C. The contracting officer, David Crouch, and other representatives from Port Hueneme attended a FEMP-sponsored regional workshop in Las Vegas, Nevada, prior to developing this DO. Staff was already very familiar with ESPC projects from prior experience with both DOE and DOD programs. Point Mugu Naval Air Weapons Station[7] (Pt. Mugu) would be the Navy's first Super ESPC DO in the western region.

The primary motivation for implementing energy conservation projects at 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 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.

For this project, the energy manager for NAV-AIR 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

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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*.

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[9], who then completed the detailed energy study in June 1999.

The final DO was signed in July 1999 for a term of 15 years. The Navy provided some additional incentives for the projects[10], 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 DO. The reduction in DO scope was due to the contract office's 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.

Table 9: Super ESPC 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 the 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.

9 ERI Services, Inc. 350 Fairfield Avenue, Bridgeport, CT 06604
10 Reportedly, the Navy will match 10% of funds spent on energy conservation projects up to $500,000

7.2.1 HVAC Upgrades

This measure will replace ten older rooftop heating and ventilating units in building 761 with two new 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 O&M 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 DDC 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:

- Installating one new boiler and two new pumps
- Decommissioning (standby) of one existing boiler and two 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[11] became closely involved during the contract development process, and participated in the development of the M&V plan. The contract 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.

[11] 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

During the development of the contract, the assigned Navy review engineer[12] requested that ERI use equipment measurements as much as possible, while still 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 measuring 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. FEMP personnel reviewed the spreadsheet models developed by ERI.

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 still 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 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. All parties agreed that measuring the baseline for these measures was prohibitive and should be modeled, and all parties agreed to the M&V plans.

7.4 Using 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 Super ESPC projects. The Pt. Mugu contract was the first they have implemented in the Western region, but they have done several Super ESPC 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 its proposed plans, which were included as a part of the DO. 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 a 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 developed further until after the detailed energy survey was performed in June 1999. The final DO was signed in July 1999. Staff reported that numerous discussions on M&V occurred over approximately two months.

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

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 replacing 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 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 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 by installing adjustable frequency drives, increasing chilled water temperature set point, resetting condenser water, and changing the pumping system.

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 decommissioning of oversized equipment. 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 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[13], 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 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 the accuracy and validity of the models used, establishment of the baseline, and accurately representing the post-installation building systems. Each of these sources is discussed below along with the M&V plan's method of addressing it.

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

7.5.1 Accuracy and Validity of Models Used

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 model's 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 additional criteria. Measured data for each subsystem may also be compared with the model predictions of subsystem 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%).

7.5.2 Accurately Representing the Post-Installation Building Systems

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 determined 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 of equipment performance. While the equipment performance will be verified, if the facility changes usage, or if there is an extreme weather year, there is a 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 is coming up for David Crouch. He had general FEMP training before. The NAV-AIR staff also attended Super ESPC 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 free services that were offered by FEMP personnel because this was the Navy's first Super ESPC project in the Western Region. Mike Holda and Steve Kromer were involved in the review of the M&V plans for this project.

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13. ABSTRACT *(Maximum 200 words)*
Schiller Associates examined the measurement and verification (M&V) plans and activities for seven Western Region Super Energy Savings Performance Contract (ESPC) projects to learn how federal agencies are implementing M&V and what factors influence M&V plan development. This report describes the method used to examine the M&V plans and presents the findings. The goals were to find common factors that influenced M&V plan development and implementation, assess risks to the agency as a result of particular M&V plans, and develop recommendations for improving M&V plan development and implementation. Participating agencies and sites were: (1) National Park Service, Yosemite National Park, CA; (2) Veterans Affairs, VA Medical Center, San Francisco, CA; (3) United States Forest Service, USFS Laboratory, Corvallis, OR; (4) Federal Aviation Administration, ATRCC, Auburn, WA; (5) United States Department of Defense, Defense Manpower Data Center, Monterey, CA; (6) United States Coast Guard, Coast Guard Station, Alameda, CA; and (7) United States Navy, Pt. Mugu, Oxnard, CA.

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