Assessing O&M Practices at Federal Facilities—What Do The ESET Data Tell Us?

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ABSTRACT

In late 2005, the Department of Energy (DOE) Federal Energy Management Program (FEMP) Energy Saving Expert Teams (ESET) conducted assessments at 28 federal sites. These assessments were directed by President Bush in a memorandum to federal agencies in response to projected natural gas shortages resulting from Hurricanes Katrina and Rita. The primary focus of the ESET assessments was to identify low-cost and no-cost (operations and maintenance-oriented) energy efficiency measures that the sites could quickly and easily adopt to relieve the expected supply shortfall, while also realizing significant energy and cost savings. The assessments successfully identified large potential natural gas savings opportunities available at low-cost/no-cost through energy efficiency measures such as boiler tune-ups, repair of steam and condensate leaks, repair of missing and/or damaged insulation, adjusting temperature and setback setpoints, and modifying equipment operating schedules. Because these savings opportunities were largely anticipated, the issue now becomes one of helping facility managers more easily identify and address these opportunities as they arise.

INTRODUCTION

President George W. Bush issued a Memorandum for the Heads of Executive Departments and Agencies, dated September 26, 2005, in response to the devastation experienced by the Gulf Coast states by

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Hurricanes Katrina and Rita in 2005, and the corresponding natural gas supply shortages and price increases. This memorandum directed the heads of executive departments and agencies to:

> "…take appropriate actions to conserve natural gas, electricity, gasoline, and diesel fuel to the maximum extent consistent with the effective discharge of public responsibilities. All agencies should conserve fuel so we can reduce overall demand and allow extra supplies to be directed towards the hurricane relief effort."

In response, the U.S. Department of Energy (DOE), Federal Energy Management Program (FEMP) formed Energy Saving Expert Teams (ESET). These teams were directed to perform energy assessments at 28 federal sites. The objectives of the ESET assessments were to identify opportunities to reduce energy use and cost, to focus on reduced consumption of natural gas, and to lead each site to more comprehensive energy savings projects.

Site assessments were conducted from October 27, 2005, through December 21, 2005. Final reports, including energy conservation opportunities and action plans, were presented to the selected sites in January 2006. The final ESET program summary report was issued in February 2006.*

ESET PROCESS

ESET teams were quickly assembled by FEMP. Individuals on the ESET teams consisted of staff from a diverse set of organizations, including DOE national laboratories, a DOE Industrial Assessment Center, several FEMP SAVEnergy contractor firms, several utilities (for sites within their service areas), and an engineering firm. Each ESET team usually consisted of two or three individuals with site visits completed in two, sometimes three, days. Sites were selected by FEMP based on several factors, with total natural gas use and availability of site staff to host an ESET team visit during the designated period being the primary factors.

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*The final ESET summary report is available at http://www1.eere.energy.gov/femp/pdfs/eset_summary.pdf.

The ESET teams were instructed to concentrate on low-cost and no-cost measures that would help the sites address current energy shortages and high prices. A protocol was developed in support of this objective. The starting point for the ESET protocol was the protocol used in site assessments completed under FEMP's ALERT* program and recommendations found in the FEMP O&M Best Practices Guide†. A copy of the assessment protocol is available at http://www.eere.energy.gov/femp/docs/eset_checklist.xls.

Teams were asked to focus their attention on the areas they felt had the greatest natural gas savings potential for each particular site, with general guidance that the greatest opportunities were probably to be found in the following areas:

- boilers,
- steam/hot water distribution systems,
- building controls,
- operations and maintenance (O&M) programs.

EXPECTATIONS

FEMP's expectations of the ESET effort were to help the sites identify a range of measures that could be quickly completed to realize energy and cost savings. The ESET assessments were not meant to be comprehensive because the time and staffing allocations (2 to 3 people for 2 to 3 days) do not allow for in-depth assessment of equipment and its operations, especially on installations with several million square feet of building space. However, past experiences provided by the ALERT assessments and numerous retro-commissioning case studies available through Portland Energy Conservation, Inc. (PECI)¶ and the Texas A&M Energy Systems Laboratory provided valuable insight into what the individual assessment findings would most likely be.

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*The ALERT (Assessment of Load and Energy Reduction Techniques) program completed approximately 75 site assessments between 2001 and 2004 to assist federal sites in responding to electric and natural gas price volatilities and shortages.

†http://www.eere.energy.gov/femp/operations_maintenance/om_best_practices_guidebook.cfm.

¶The PECI website (http://www.peci.org/library.htm) makes available numerous case studies and publications on commissioning and retro-commissioning, as well as links to other organizations dealing with these topics.

- Most likely opportunities available to reduce winter heating costs* are:

  — Optimize air-to-fuel ratio for fired systems.
  — Inspect and repair burner systems.
  — Have an active steam trap maintenance program.
  — Repair steam and condensate leaks and return condensate to the boilers.
  — Inspect and improve insulation of heated pipes and equipment.
  — Reduce boiler cycling losses.
  — Minimize boiler blowdown.

- Most likely opportunities available year-round† are:

  — Fully utilize control system capabilities.
  — Correct system overrides.
  — Adjust reset temperatures and temperature settings.
  — Control time of use.
  — Repair dampers and economizers.

FINDINGS

The following data are taken from the ESET summary report and represent combined data for all 28 sites.

- The annual (baseline) natural gas consumption for the 28 sites visited totaled 10,940,011 million Btus (MMBtu).

- Potential natural gas savings opportunities identified totaled 970,764 MMBtu per year, or a reduction potential of 8.9 percent of the total natural gas consumption.

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*These opportunities are summarized in the fact sheet "Tutorial II: Actions You Can Take to Reduce Winter Heating Costs" available at http://www.eere.energy.gov/femp/pdfs/om_combustion.pdf.

†These opportunities are summarized in the fact sheet "Tutorial: Five O&M Ideas on How to Save Money in Your Buildings NOW!" available at http://www.eere.energy.gov/femp/pdfs/om_savemoney.pdf.

- Potential annual natural gas cost savings of $6.7 million based on a 2004 average cost of $6.86/mmBtu.

- Potential electrical savings opportunities identified represented a reduction of 1.8 percent of the total electrical consumption, an annual savings of $3.6 million based on a 2004 average cost of $19.48/mmBtu.

- The total estimated cost to complete the low-cost recommendations (those costing less than $20,000 and/or having a simple payback of less than 2 years) is $8.0 million.

Of greater interest are the emerging trends in terms of identified energy conservation opportunities. Unfortunately, the protocol was not as widely applied as anticipated because several of the teams focused more on identifying retrofit measures than the low-cost/no-cost measures intended by the ESET protocol. [In the context of this article, a retrofit measure is defined as an energy efficiency measure that, regardless of simple payback period, either a) changes out existing equipment for similar or more efficient equipment, or b) adds new equipment to existing systems (e.g., variable speed drives to fans or pumping systems).] However, in cases where the protocol was applied, the results were largely along the lines of those expected. Below is a summary of the most frequent low-cost/no-cost findings identified for boilers and steam/hot water distribution systems.

- There were opportunities for boiler tune-ups in virtually every case where the boilers were tested. Many of the boilers tested were found to have levels of excess oxygen well above the targeted 2 percent (in high fire) to 4 percent range (in low fire), indicating the need to adjust air-to-fuel ratios.

- High stack temperatures, which most likely result from poor heat transfer caused by scale in the boiler tubes (water treatment issue) or soot on the boiler tubes (a burner and/or air flow issue), was another frequent finding.

- None of the visited sites was found to have an effective steam trap maintenance program in place. Steam trap maintenance programs

minimize the number of failed steam traps on an ongoing basis. Steam traps failing in the open position are especially problematic because they not only allow large amounts of expensive steam to pass through to the condensate system without accomplishing useful work, but they also go undetected until steam traps are tested. Steam traps failing in the closed position usually result in trouble calls because of the apparent localized loss of steam service. A steam distribution system that has not had an ongoing trap maintenance program will very likely have a high trap failure rate during its initial inspection. Large numbers of trap failures can require significant investment above the local O&M budget authority, requiring repairs and alterations projects to correct.

- Steam system leaks were noted in several of the assessments. As with the case for steam traps, leaking steam can be very costly. Several of the assessments also cited low condensate returns, requiring corrective actions that will likely require significant repair and alterations projects to correct.

- Missing insulation on boilers and steam and hot water lines, valves, and fittings was found in virtually every assessment report where heating plants and/or distribution systems were inspected. There were several places where large portions of insulation were either missing or possibly never even applied. Because most of these cases consisted of small amounts of uninsulated sections scattered about, we assume that the missing insulation had probably been damaged and never replaced.

- Less frequently cited findings included boiler short cycling and questions regarding boiler blowdown procedures.

The following are the most frequently identified controls systems deficiencies/opportunities (in descending order of frequency):

- Absence of night temperature setbacks.

- Opportunity to reduce temperature setpoints.

- Changes of equipment operating schedules to coincide with building operating hours.

- Simultaneous heating and cooling.
- System programming—correct overrides and enable system features.

Finally, while there were many low-cost/no-cost opportunities identified through ESET assessments of federal buildings, these findings mirror the findings of the numerous case studies of public and non-public sector buildings reviewed prior to the ESET effort. Therefore, it would appear to be reasonable to accept that energy intensive equipment and systems in federal buildings are operated and maintained in a manner similar to their private sector counterparts.

DIFFERENT APPROACHES—DIFFERENT RESULTS: RETROFIT PROJECTS VERSUS LOW-COST (O&M) ACTIONS

As previously noted, not all the assessment teams followed the assessment protocol. Deviations were usually along the lines of the "standard" energy audit focusing on identifying potential retrofit projects. This is a somewhat standardized approach in the energy management field, yet it is an approach that should be carefully re-examined, as the following example demonstrates.

One of the sites visited has 19 boilers, eight of which were tested during the ESET visit. The table, opposite, contains the reported data for the eight tested boilers.

Note that the data presented in the assessment report do not include the following:

- What the boilers are producing—steam or hot water and at what pressure or temperature.
- Boiler fuel—while we are inclined to assume the boilers were firing with natural gas because natural gas reduction was the basis for the ESET visits, we really need to verify the fuel being used.
- If the testing was done under low- or high-fire conditions.
- Testing equipment used—optional in this case but potentially helpful.

Boiler House	*O_2 (%)*	*CO_2 (%)*	*Ambient Temperature*	*Efficiency (%)*	*CO (PPM)*	*CO Referenced*	*Stack Temperature*	*Excess Air (%)*
1	4.4	9.3	81.5	83.3	20	26	358	24
2	5.9	8.5	69.5	81.7	4	6	380	35
3	5.8	8.5	67	82.7	11	15	347	34
4	4.7	9.1	70.5	84.3	0	0	307	26
5	4.1	9.5	67	75.7	0	0	442	22
6	12.6	4.7	80	70.6	40	99	395	135
7	11.5	5.3	85	80.3	79	176	328	109
8	9.5	6.4	72	80.8	1	2	346	74

The following two boiler-related recommendations contained in the report are of interest to this example:

- Install heat recovery systems because, "The high stack temperatures indicate there is a potential to recover a significant amount of heat that is currently being wasted." Estimated cost to install on 19 boilers (assuming remaining 11 untested boilers offer the same opportunity) is $475,000.

- Install oxygen trim systems at $25,000 per installation or $475,000 for all 19 boilers.

However, the following recommendations would likely be made using a low-cost O&M approach:

- The apparently high stack temperatures first need to be evaluated based on what the boiler is producing. The target temperature for exhaust stack gases is usually 100°F to 150°F above the saturated liquid temperature. Because we don't know what the boiler is producing or the drum water temperature, we can't really tell if the stack temperatures are too high. Still, it is very likely that stack temperatures of 442°F and 395°F are excessive. In this case the question of "why?" needs to be addressed, and the answer may be scale build-up in the boiler tubes. If the elevated stack temperatures are the result of scale build up, an improved water treatment strategy along with scale removal may be a more appropriate approach.

- Based on the oxygen levels, a boiler tune-up is in order. Measured oxygen should be in the range of 2 percent (in high fire) to 4 percent (in low fire), with lower being better. All the boilers tested were outside this range (we don't know if boilers were tested in low fire or high fire) with some having very high readings. However, boilers 6 and 7 are showing elevated CO levels. This may be a sign of a worn burner not achieving a good air-fuel mix. Simply reducing excess air may elevate these CO levels further. See table on following page.

While both evaluation approaches agree that there is a significant opportunity for improvement in these boilers' operations, the solu-

tions proposed in the assessment report are very different in terms of cost than the recommendations expected from a low-cost approach. The retrofit approach proposes $950,000 worth of projects, while the low-cost approach would make recommendations that a) could be completed by on-site staff, and b) should be completed as part of the scheduled maintenance program. It is true that staff time to complete the actions, testing equipment to aid in the diagnostics, and annual training to develop and maintain staff capabilities are all required for the low-cost approach to work, but these resources are still required if the recommended retrofits are installed. Finally, the justification of the heat recovery systems is based largely on the fact that the boilers are operating very inefficiently; in this case, the retrofit may well work to accommodate the inefficiency instead of addressing it.

FROM FINDINGS TO SOLUTIONS

How should the sites visited and the rest of the federal sector respond to the ESET findings? One option is to maintain the status quo, where continuing to pay the utility bills and replacing equipment upon failure can often be viewed as a low-risk approach because utility funding and project funding to replace failed equipment may be easier to obtain than funding for improved O&M. The ESET program recognizes this (faulty) rationale and instead concentrates on identifying low-cost/no-cost improvement opportunities that, when fully adopted, will work to increase local funding availability by optimizing the impact: reduced energy bills, improved services, more reliable operations, increased service life, and improved safety conditions.

Below is a solution set containing several possible measures for all federal sites to consider. None of these measures alone will capture all the efficiency opportunities identified in this series of ESET assessments. Sites that cannot adopt all the recommended measures should prioritize and adopt them based on expected return on investment.

- Provide regularly scheduled training at the operator level: Most of the low-cost/no-cost deficiencies were expected because these deficiencies are typical of most facility assessments. Also typical of these measures is that they can be addressed by site staff that are properly trained, provided they have the resources of time and

testing equipment. Training must be ongoing for staff to maintain proficiency and to familiarize new staff with capabilities and requirements of the systems they have recently been assigned to. Training courses on boiler operations, controls theory and system specific capabilities and operation, and boiler water treatment should be provided to operators once every two years or when newly assigned to operate these systems. And while chillers, air conditioners, and refrigeration systems were not included in these ESET assessments, previous case studies and ALERT assessments allow us to reasonably conclude that similar opportunities and needs are present for these systems as well.

- Provide training at the facilities management level: Demonstrate to decision makers that many of the predictable deficiencies can be easily corrected through reallocation and prioritization of resources, and why these deficiencies should be assigned a high priority. This training course should include information on the training needs of the practitioners, equipment necessary to monitor status and diagnose operations, and improving O&M contract language and administration.

- Require proactive O&M as part of O&M contracts: Improve contract language by requiring certain actions such as achieving and maintaining minimum boiler efficiencies and proper building and equipment scheduling. Address how the site verifies actions being completed under current contract, and identify areas and methods for improvement as needed. Consider using contract incentives where contractors receive awards from energy savings for operating energy intensive systems more efficiently. In this case, the verification of completed work could be done by evaluating energy use data instead of completion of individual measures.

- Testing equipment needs to be available for certain equipment. Sites operating boilers using natural gas in excess of $50,000 per year* should purchase a portable combustion gas analyzer and have it

*This estimate assumes a conservative boiler combustion efficiency improvement of 2 percent per year, a purchase cost of $2,000 for a combustion gas analyzer, and a simple payback period of 2 years. Economics become more favorable as the total gas usage for boilers increases.

regularly maintained and calibrated. Sites relying on natural gas should also purchase gas leak detectors for safety as well as energy efficiency purposes.

Beyond the site level, the frequency of boiler efficiency, steam trap, steam and hot water distribution line insulation, and controls (i.e., setbacks, setpoints, programming, etc.) deficiencies may present an opportunity for new government-wide contracting mechanisms. These new contracting mechanisms could allow sites to tap into pre-awarded procurement vehicles that access specialized services such as boiler tune-ups, controls systems tune-ups, steam trap repair and steam trap maintenance program development, and insulation repair and replacement. Payment for contracting services should allow for the option of direct payment or for payment as part of the realized savings over time. Because the measures included under these procurement vehicles are all low-cost with simple payback periods of less than two years (and sometimes on the order of several weeks), repayment terms would be capped at two to four years. Such services and procurement mechanisms would allow the sites to quickly access the desired services, make changes in a timely manner, and make available short-term financing when needed.

CONCLUSIONS

There are several conclusions that can be reached from the recent round of ESET assessments.

- The ESET assessments were largely successful; significant low-cost/no-cost natural gas savings measures were identified. These findings and their recommendations (assuming quick adoption at the visited sites) satisfied the overall objective of the ESET effort to help agencies "…take appropriate actions to conserve natural gas, electricity, gasoline, and diesel fuel to the maximum extent consistent with the effective discharge of public responsibilities."

- The expected findings were consistent with on-site observations when the ESET protocol was followed. The implications from this conclusion are significant:

— The need for further assessments of low-cost opportunities in federal facilities is greatly reduced at the program level because we have a high confidence that the most likely deficiencies across the facility inventory are known.

— Addressing the deficiencies can be done at both the site level through training, testing, and contracting, as well as at the national level through contracting mechanisms offering specialized low-cost measure actions (e.g., controls modifications) with flexible financing arrangements.

- Low-cost opportunities need to be given priority consideration, especially in cases where these types of measures offer a cost-effective alternative to capital intensive retrofit projects, which is often the case.

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