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Reductions in Energy and Water Use in a Government Laboratory through An Energy Savings Performance Contract (ESPC)

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ABSTRACT

The USDA's Agricultural Research Service Center for Medical, Agricultural, and Veterinary Entomology is constantly looking for ways to reduce its energy and water use while still delivering world-class research in a comfortable and safe facility. Over the years, the federal facility has achieved reductions by teaming up with its local utility provider. More recently, it participated in an energy savings performance contract (ESPC) with an energy services company to radically reduce its total energy use from 28,974 MBtu/yr to 23,413 MBtu/yr, and its water use from 426.4 Kgal/yr to 182.0 Kgal/yr while maintaining occupant safety and comfort. The unique features of an ESPC allow any federal facility to accomplish energy savings projects without up-front capital outlays. Both in-house small projects and large projects can be accomplished through the ESPC process using private financing, with implementation costs and debt service paid for out of energy savings.

INTRODUCTION

The Center for Medical, Agricultural, and Veterinary Entomology (CMAVE), located in Gainesville, Florida, is a federal research facility in the Agricultural Research Service, an agency of the USDA. CMAVE is composed of four research units (comprising almost 60 scientists and 140 support personnel) conducting studies designed to control insects that damage and transmit diseases to plants, animals, and humans.[1] Established in its present location in 1962, it consists of two large research buildings and over 30 smaller buildings used for insect rearing and testing, storage, and offices. At the end of the last decade, managers at the facility recognized the need to do something to reduce their ever-increasing energy costs in order to safeguard funding for research projects, as well as to comply with statutes and presidential executive orders to reduce energy use in all federal facilities.[2,3,4,5] The energy-saving strategy they adopted was both administrative and engineered. The resulting policies required the purchase of energy efficient equipment and appliances and encouraged energy-saving personal behaviors in the workplace. Working with the local utility provider, they accomplished several small energy savings projects that were paid for out of the regular facility operations budget and were offset by utility rebates in some cases. They were able to convert all their older T-12 fluorescent lamps to newer and more efficient T-8 lamps.[6] Also, many ground floor single-pane windows were replaced with large, energy efficient, impact-resistant windows. Although these projects were helpful, they represented only nominal progress towards the goal established by Congress and the administration to reduce energy use 30% from 2003 levels by 2020. In 2007, facility managers decided that dramatic reductions would require major modifications to their current infrastructure. After consultation with the Department of Energy, the Agricultural Research Service decided to enter into an energy savings performance contract (ESPC) with an energy services company, which allows a federal agency to accomplish energy savings projects without up-front capital costs and without special Congressional appropriations.[7]

PARTICIPATION IN AN ESPC

In 2007, the laboratory formed a procurement team that reviewed candidate energy savings companies and ultimately selected Chevron

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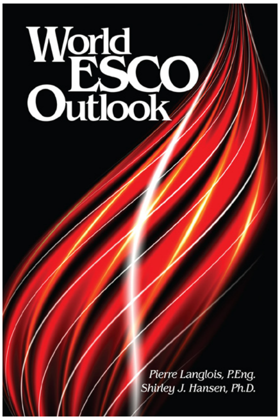

In any rapidly evolving industry, the need to stay current is crucial. The energy service company (ESCO) industry is a moving target. As country after country around the world embraces the idea of self-funding energy efficiency, an energy performance contracting (EPC) model emerges and then changes to meet local needs. An explosion of new variations is out there. World ESCO Outlook captures this rapidly changing landscape, and offers valuable insights into this fascinating and important industry. The authors have brought together the best of in-country experts from nearly 60 countries to share their knowledge and experience as to what makes EPC successful in their specific environments. In telling their story, they also reveal some exciting new overseas market opportunities, and provide the most complete picture available of today's ESCO world.

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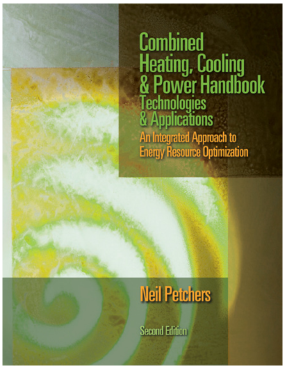

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Energy Solutions Company, a Division of Chevron U.S.A., Inc. Chevron conducted a preliminary analysis, followed by a detailed energy study. After the laboratory's review of these two studies, the agency issued a task order, after which Chevron designed and constructed the project. A detailed audit of energy and water use from May 2008 to April 2009 provided the baseline data used to calculate future energy savings. The guaranteed savings in CMAVE's energy bill, a feature of the contract, is being used to service the project's financing. Energy savings are measured and verified annually following the first year post-construction, with adjustments made for billing day cycle variations and weather variations. The energy savings that are reported here result from a comparison of energy and water use during the base year, before construction, and the energy and water use during the first year after project completion (May 2010—April 2011). The analysis also incorporated a 3% rate increase in the cost of electricity, gas, and water from the base year, as well as an adjustment for variations in utility calendar-day billing.

ACCOMPLISHING ENERGY CONSERVATION MEASURES

Construction began in July of 2009 and was completed in May of 2010. Chevron "bundled" several energy conservation measures (ECMs). Building 1 is a 25,000-sq-ft, single-story laboratory complex built in 1962. Modification of the ventilation system in Building 1 (identified as ECM 1A in Table 1) was identified as the ECM most likely to generate the greatest savings and allow for the incorporation of longer payback ECMs. The cooling load requirement for the laboratory facility is much greater than a conventional building because it requires that 100% outside air be used to meet ventilation requirements, and laboratories containing hazardous chemicals must be constantly maintained under negative pressure relative to corridors and office space.[8,9] Modifications included improving sash operation on all 15 fume hoods, installing automatic sash positioning systems (ASPSs) on 6 fume hoods, installing sash stops on the remaining hoods, and retrofitting the existing exhaust system by adding a bypass with static pressure controls near the fan inlet. Engineers also revised minimum and maximum flow setpoints and modified controllers and programming for variable-flow operation. Finally, cooling coils were cleaned and all filters replaced. This ECM alone accounted for 47.1% of the total energy saved in the first year. (See Table 2.)

Additional first-year savings were derived from ECM 1B, an upgrade of the ventilation system in Building 11, a 50,000 sq ft, two-story laboratory complex built in 1968. In this building, sash operation was improved in all 48 fume hoods and sash stops were installed. Further, engineers either replaced bypass damper actuators on exhaust fans or, in some cases, installed new bypass dampers. Another energy-saving

Table 1. Description of the Energy Conservation Measures in the ESCP

ECM	*Description*
1A	Building 1 Laboratory Ventilation System Upgrade
1B	Building 11 Laboratory Ventilation System Upgrade
2A	Building 1 Summer Boiler Addition
2B	Building 11 Summer Boiler Addition
3B	Building 11 Chiller Replacement
4	Water Conservation
5	HVAC Controls Update
6	Irrigation System Sub-Meter Addition
8	Refrigeration Unit Addition (Walk-In Cooler)

Table 2. ECM and total verified savings for first year of measurement and verification.

ECM	*Projected Energy Saved in MBtu*	*Verified Energy Saved in MBtu*	*Projected Annual Energy Savings*	*Verified Energy Saved*	*Verified Non-Energy Saved*	*Total cost savings, $/yr*	*Excess Savings*
1A	1817	2,773	$32,293	$62,090	—	$62,090	$30,088
1B	1343	604	$26,710	$13,882	—	$13,882	($12587)
2A	353	414	$4,240	$4,907	—	$4,907	$706
2B	468	449	$5,767	$5,318	—	$5,318	($397)
3B	957	1,111	$31,251	$36,296	—	$36,296	$5,326
4	—	—	$1,509	$0	$1,509	$1,509	$14
5	189	189	$5,777	$5,777	—	$5,777	$52
6	—	—	—	$0	$1,497	$1,497	($185)
8	21	21	$685	$685	—	$685	$6
Total Savings	5147	5,561	$106,723	$128,957	$3,006	$131,963	$23,024

Note: Table includes an escalation rate of three percent for electricity, natural gas, water and sewer. Non energy-related O&M costs for year 1 are not accounted for in the total cost savings.

feature was adding an unoccupied setback sequence of control for the fume hood exhaust, thus reducing the number of room air replacements per hour (from eight to four) when a lab is unoccupied. As in Building 1, cooling coils were cleaned and all filters replaced. These modifications accounted for 604 MBtu/yr in energy savings (10.5% of the total first-year energy savings). However, while an analysis before construction predicted the energy savings for this ECM to be 1343 MBtu/yr., actual savings were 47.6% lower than predicted, specifically due to unrelated mechanical trouble with three of the four air-handlers during the M&V year. These issues have been resolved, and the system is now delivering 100% of the expected energy savings. An additional benefit of ECM 1A and ECM 1B is an improvement in occupant comfort due to a more tightly controlled and stable laboratory environment.

The original boilers were determined to be oversized for the climate in northern Florida, resulting in inefficient short-cycling for most of the year. A smaller, 750-MBH (thousand Btu/hour) condensing boiler was installed in Building 1 for reheating conditioned air (ECM 2A). Likewise, a smaller (1,500-MBH) condensing boiler was installed in Building 11 next to the original 4185-MBH boiler (ECM 2B). This smaller boiler meets the needs of the building most of the year, allowing the larger boiler to be on standby. In addition, controls were tied into a building automation system (BAS) incorporating a hot water supply temperature reset strategy. The Building 1 HW system was converted to variable-volume flow (new VFD with differential pressure controls). These changes resulted in a 7.7% reduction in first-year natural gas energy costs. (See Figures 1 and 2.) Natural gas use during the M&V year was lower than the base year, except in December and January in Building 1 and December in Building 11. Use was higher in these months because it was an unusually cold winter.

ECM 3B entailed the replacement of one of the two 10-yr-old, 240-ton chillers with a new Smardt air-cooled unit. These two chillers are generating chilled water for the air handling units (AHU) in Building 11 and the AHUs serving a 3,100-sq-ft greenhouse. The chilled water system is configured for variable-volume flow in a distribution loop by utilizing a primary-secondary pumping arrangement. The new, quieter chiller (which uses a frictionless, magnetic-bearing refrigerant compressor more efficient at handling partial loads) has a 19.0 energy efficiency ratio (EER) compared with 12.7 EER in the original chiller. The new chiller uses R-134, a refrigerant which is environmentally friendlier

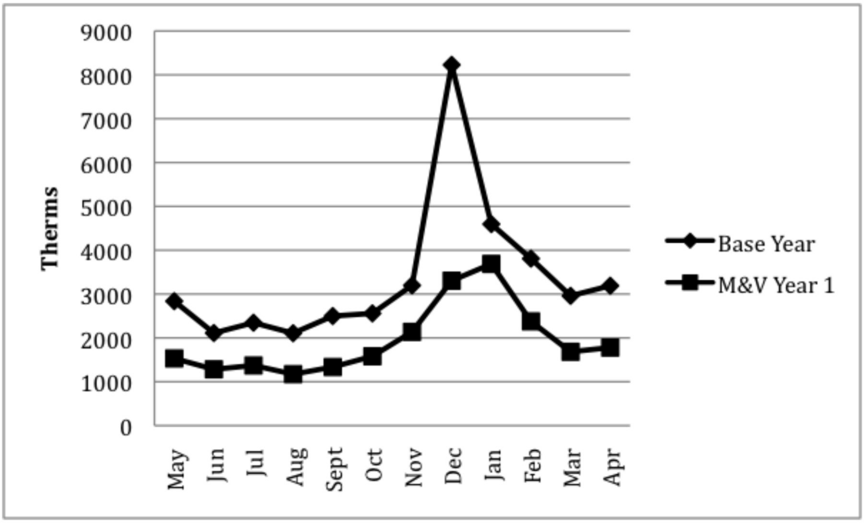

Figure 1. Natural gas usage Building 1 2010-2011. Data adjusted for weather and billing day variations between base year and M&V year.

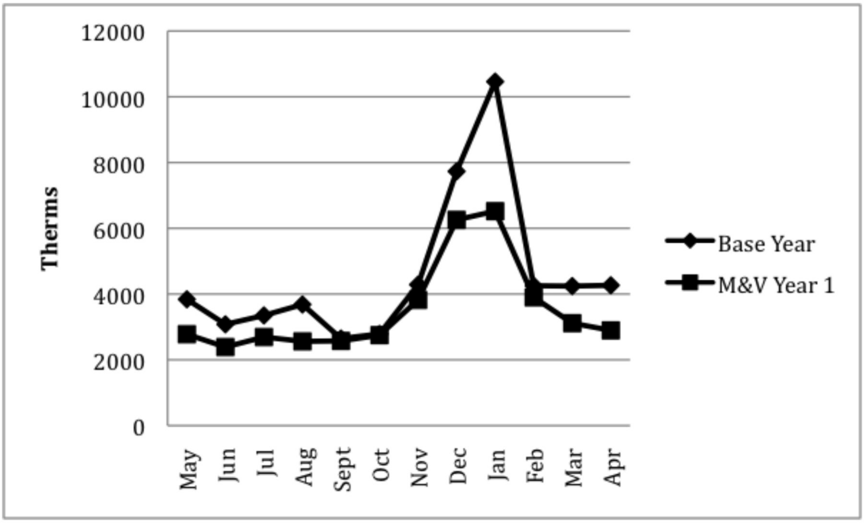

Figure 2. Natural gas usage Building 11 2010-2011. Data adjusted for weather and billing day variations between base year and M&V year.

than the R-22 refrigerant in the chiller it replaced.[10] Incorporating this efficient chiller into the project accounted for 27.5% of the total energy saved, reducing energy usage below base year values in ten of twelve months; exceptionally high ambient temperatures occurred during the months of July and April when M&V year energy use values exceeded base year values. (See Figure 3.)

Water use was reduced by replacing 20 old water closets, 10 urinals, and 4 sinks with high efficiency, low consumption fixtures (ECM 4). Water usage dropped from 424.4 to 182.0 Kgal/yr because of this ECM, a reduction of 57.3%. (See Figure 4.)

A 3.39% reduction in the total energy saved was accomplished by installing a manual switch in the greenhouse to allow space temperature setback during non-test periods (ECM 5). Control software was also modified to include high and low space temperature limits during non-test periods.

ECM 6 and ECM 8 were the result of innovative thinking. Water submeters were installed in an adjoining research field to avoid sewer costs. (Water use in the field is for irrigation of crops and never enters the sewer system.) Water usage was not reduced, but utility costs

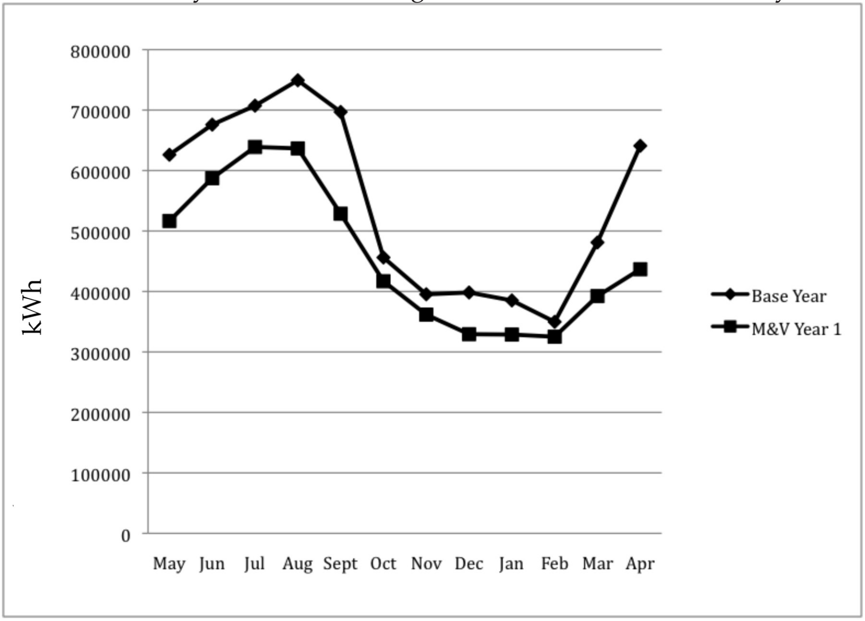

Figure 3. Electricity usage at facility 2010-2011. Data adjusted for weather and billing day variations between base year and M&V year.

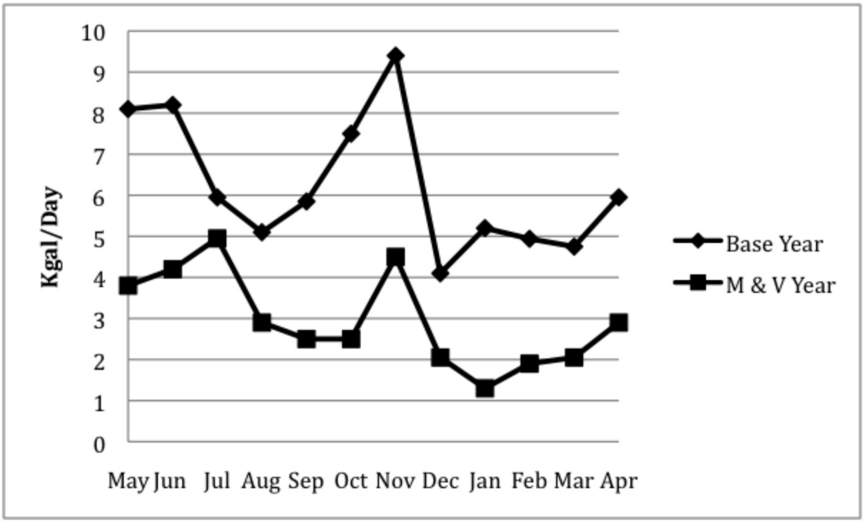

Figure 4. Water usage at facility 2010-2011.

were. A previously unused walk-in cooler was upgraded with a new refrigerant unit. Employees voluntarily cooperated with managers to shut down several individual refrigerators and began using the walk-in cooler. Though this represents an inconvenience to employees who work elsewhere in the building, it is an ongoing opportunity for employees to show their commitment to the environmental management system (EMS) at CMAVE. These two projects combined resulted in 1.1% of the electrical energy saved.

CONCLUSIONS

Electrical costs represent the largest part of the annual utility bill. The ESPC project has already significantly reduced electricity usage, with CMAVE's total annual energy costs reduced by $131,963 in the first year, more than $23,000 greater than expected. (The money saved in excess of the guaranteed amount is available for research.) In addition, the facility is complying with Congressional and administration targets for energy and water-use reductions. The present annual cost of energy at CMAVE is approximately three-quarters of a million dollars. As energy rates increase, the value of these improvements will increase.

Federal facilities can accomplish small energy savings projects through the normal facilities operational budget. However, large projects that radically modify the engineering and infrastructure of a facility may benefit from an ESPC or a similar process. Midway through the first year of measurement and verification, CMAVE installed an 80-ft^2 solar water heater panel on the roof of Building 11. (An identical one is planned for Building 1.) This solar-heated water feeds directly into the building's circulating hot water, further reducing energy costs. This project was not part of the ESPC, and an exact accounting of the impact on savings has not been done. It demonstrates that an ESPC and funding through the regular operational budget together can result in resource conservation improvements.

Acknowledgments

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