Methodology for the Evaluation of an Energy Savings Performance Contracting Program for the U.S. Federal Government

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ABSTRACT

An Energy Savings Performance Contract (ESPC) is a method of funding energy conservation measures using the cost savings that result from the measures themselves. Currently the most widely used vehicles for implementing ESPCs in the U.S. federal government are the Super ESPC contracts administered by the U.S. Department of Energy's Federal Energy Management Program. The principal objective of an evaluation being carried out by the authors is to compare the cost and energy savings predicted for Super ESPCs with the actual savings achieved by those projects to date. The evaluation uses a three-tier nested design, with increasingly intensive and more rigorous methods being applied to smaller and smaller samples. A key feature of Super ESPCs is the requirement for ESCOs to produce annual measurement and verification (M&V) reports, and the first tier of the evaluation is based on review of the most recent annual M&V reports for all Super ESPC projects in their performance periods to compare reported savings with guaranteed savings. The second tier of the evaluation focuses on a stratified random sample of 25 projects, with the objective of recalculating the savings reported in the most recent annual M&V report according to the algorithms specified in the contracts. Analysis in Tier 3 is focused on a smaller subsample of projects that meet validity criteria for whole-building or whole-facility data analysis, with the objective of comparing pre- and post-retrofit energy costs to verify the savings that have been achieved. This paper presents an overview of the evaluation design, describes the criteria for selection of the subsample, and includes preliminary results from Tier 1.

Introduction

Among the most widely used vehicles for implementing energy savings performance contract (ESPC) projects in the federal government are the regional and technology-specific Super ESPCs administered by the U.S. Department of Energy's (DOE's) Federal Energy Management Program (FEMP). Super ESPCs are indefinite-delivery, indefinite-quantity (IDIQ) contracts designed to make ESPCs as practical and cost-effective a tool as possible for federal agencies to use. These "umbrella" contracts were competitively awarded to energy services companies (ESCOs) who demonstrated their capabilities to provide energy projects to federal customers. The general terms and conditions are established in the IDIQ contracts, and agencies implement projects by awarding delivery orders to the Super ESPC ESCOs. Using IDIQ contracts, agencies can implement Super ESPC projects in far less time than it takes to develop stand-alone ESPC projects. Since 1998, federal agencies have used Super ESPCs to install more than $900 million worth of energy improvements.

The principal objective of the evaluation being carried out by Oak Ridge National Laboratory (ORNL) for FEMP is to compare predicted and guaranteed Super ESPC cost and energy savings with the savings actually achieved. ESCOs guarantee a certain amount of cost savings to be delivered by their ESPC projects, based on their estimates (or predictions) of energy and cost savings that the project will deliver.

Energy savings are not formally guaranteed in the contracts, but they form the basis for the guaranteed cost savings. At least once per year in each ongoing ESPC project, the ESCO carries out a series of activities designed to verify that the installed equipment is operational and that energy and cost savings are being delivered, and to determine whether cost savings guarantees were met for the reporting period. These measurement and verification (M&V) activities are carried out in accordance with an M&V plan that is part of the contract between the agency and ESCO. Hence, the specific activities such as ESCO inspections, measurements and engineering calculations, and witnessing of these activities by agency personnel vary by project. The results of the M&V activities are reported to the agency in the form of an annual M&V report. These annual reports are the primary source of information for the evaluation.

Methodology

The evaluation of the Super ESPC program uses a three-tier, nested design (Figure 1), with increasingly more intensive and rigorous methods being applied to smaller and smaller samples.

The first tier of the study reviews the latest M&V report for each ongoing Super ESPC project. This includes all active Super ESPC projects for which the relevant improvements were completed and accepted by the government by April 2005. This date was chosen because it allows at least one full year of performance for which an annual M&V report can be produced before the initiation of data collection for this study. For each project included in the study population, the energy and cost savings documented by the ESCO in the latest M&V report are recorded. The ESCO-reported savings is compared to the guaranteed cost savings and to the predicted (or "estimated") energy savings on which those guarantees are based.

Tier 2 of the study focuses on a subsample of ongoing Super ESPC projects, stratified by U.S. census region and status with respect to August 2001 modifications to the Super ESPC IDIQs. The regional and technology-specific Super ESPC IDIQ contracts were awarded in a series beginning in 1998, and improvements resulting from lessons learned while establishing the earlier contracts were incorporated into the later Super ESPCs. The modifications made to the Super ESPC IDIQs after August 2001 eliminated the differences between the regional contacts, making them all consistent across the program. The standardization and uniformity of the contracts and project documents, especially the financial schedules, was intended to improve quality assurance and administration of Super ESPC projects.

For the sampled projects, savings reported in the most recent M&V report are recalculated employing the approach specified in the M&V plan and, to the extent possible, using improved data in place of previously used values for key factors that influence energy consumption and costs. The Tier 2 approach consists of verifying all the math from the earlier calculations, verifying to the extent possible the savings associated with reduced energy-related operations and maintenance (O&M) and repair and replacement (R&R) expenses, substituting measured values for some stipulated values and, where possible, using measured values for key parameters.

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The Tier 3 analysis is conducted for a much smaller subsample that meets validity criteria for whole-building or whole-facility data analysis. This effort measures verified energy and cost savings

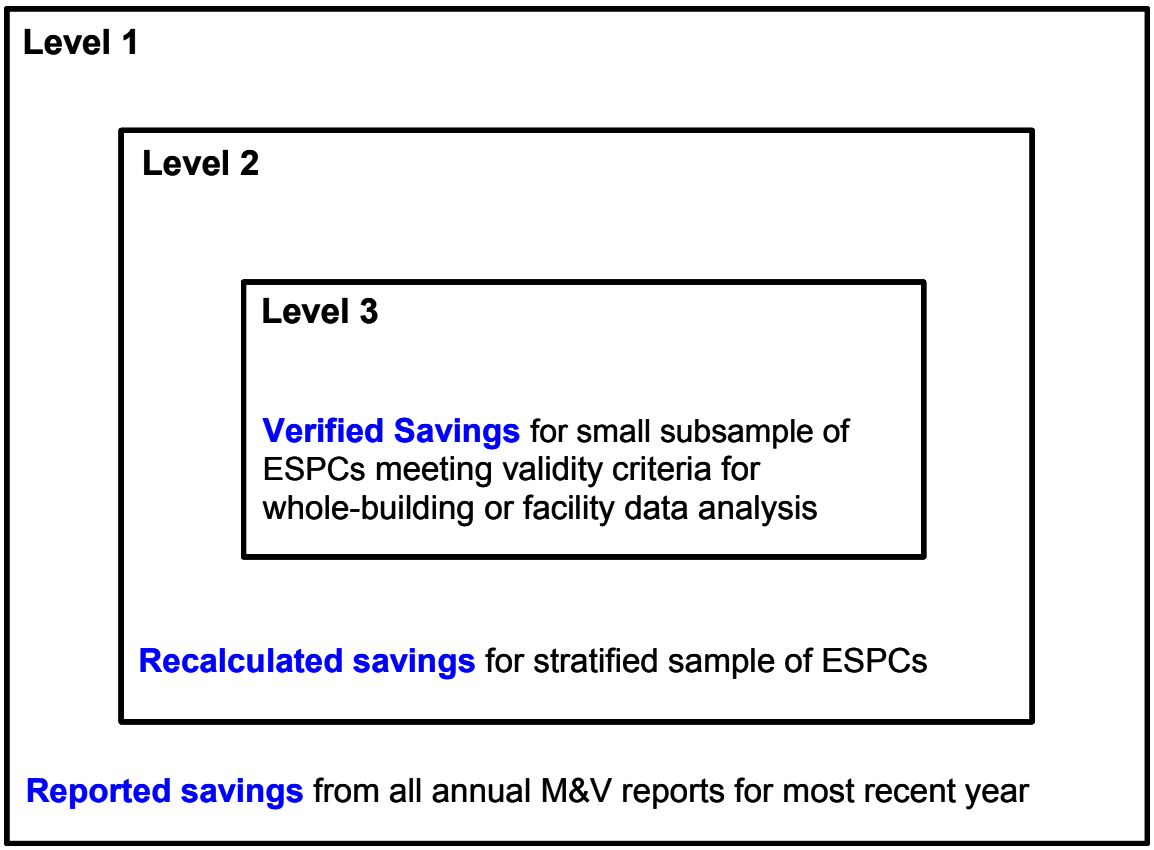

Figure 1: Schematic of evaluation design.

under real-world conditions for a set of three to five Super ESPC projects. Examples of this type of analysis are presented by Shonder and Florita (2003) and Shonder and Hughes (2005).

The findings from each tier are used in conjunction with the findings from the other two tiers to optimize the value of this evaluation. Specifically, the Tier 3 data are used to corroborate the Tier 2 findings and to suggest any necessary refinements to the Tier 2 numbers. This approach of using intensive case studies to corroborate and flesh out the findings from less-intensive studies of larger numbers of subjects is frequently used in the evaluation field (e.g., Berry, Brown, Wright, and White 1991; U.S. Nuclear Regulatory Commission 1996). In turn, the adjustment factors produced through the Tier 2 and 3 analyses are applied to the reported savings documented in Tier 1 to estimate total verified savings from all implemented projects.

Sample Selection

The population of ESPC projects eligible for inclusion in the Tier 2 sample consists of 102 projects. This population includes all of the Super ESPC projects that were in the performance period and for which at least one annual M&V report had been produced by April 2006. Two categories were used to ensure representation of all important strata in the sample. The first was census region. ESPC contracts are multi-year agreements that must anticipate future changes in fuel prices at the time of award. Most Super ESPC contracts use the figures provided by NIST (U.S. Department of Commerce 2006) which project fuel prices by census region for a thirty-year planning horizon. The sample was stratified by census region to determine how well these projections tracked actual increases in fuel prices over time.

The second category used to develop the Tier 2 sample was status with respect to the consistency modifications (mentioned in the Methodology section).

The variation in ESPC project sizes is enormous, with the largest ESPC project having guaranteed cost savings about 300 times larger than the guaranteed cost savings of the smallest project. Because large projects have much greater potential than small projects to affect net savings for the entire population, project size was also used as a basis for sampling. However, rather than stratifying by project size, projects were selected using probability-proportional-to-size (PPS) sampling.

In choosing a size for the Tier 2 sample, the goal was to be able to estimate recalculated whole-project cost savings as a proportion of guaranteed savings to within 5 percent of the mean value for that parameter for the entire population of Super ESPCs at a 90 percent confidence level. Although they lead to a more efficient sampling design, stratification and PPS sampling complicate the problem of reckoning a necessary sample size. Therefore several simplifying assumptions were made to reckon an overall sample size. As an approximation, the sample size was determined for a design with simple random (as opposed to PPS) sampling and without any stratification. This sample size should exceed the sample size necessary for the stratified and PPS-sampled design. As an additional approximation for reckoning sample size, it was assumed that verified savings for individual projects would be within a certain distance of the guaranteed savings and that a specific confidence interval was desired. Calculations were performed using a variety of assumptions (e.g., verified savings as a percentage of guaranteed savings being uniformly distributed between 80 and 120 percent; verified savings as a percentage of guaranteed savings being binomially distributed at 90 percent and 110 percent) and with both 0.9 and 0.95 confidence levels. The results indicate that a sample size of 25 is adequate to provide accurate results under a variety of conditions.

Preliminary Tier 1 Results

Reported and Guaranteed Cost Savings

Although the primary objective of an ESPC project is to reduce energy use, the most important issue contractually is cost savings, which are guaranteed on an annual basis by the ESCO. Reductions in energy use are usually the largest source of the cost savings, but savings can also come from reductions in demand, improved power factor (which sometimes results in lower utility rates), and reductions in water use. Reduced O&M and R&R costs are another major source of savings in ESPC projects.

The first objective of the Tier 1 analysis was to determine the aggregate reported and guaranteed annual cost savings for the Super ESPC program. Altogether it was possible to determine reported and guaranteed cost savings for 100 of the 102 reports received. The total annual guaranteed cost savings for the 100 projects for the periods covered was $42.9 million, and the total reported cost savings was $46.4 million. In the aggregate, reported cost savings were 108% of the cost savings guarantees.

In 12 of the 100 projects, the reported annual cost savings were equal to the guaranteed cost savings, suggesting that all of the savings in these projects were stipulated. When these projects are excluded, the total reported cost savings in the other 88 projects was 110% of the total guaranteed cost savings.

Of the 88 non-stipulated projects, 81 reported annual cost savings greater than the guaranteed cost savings. The average amount of the additional cost saving was 12% of the guaranteed cost savings.

Cost savings shortfalls were reported in 7 of the 88 non-stipulated projects. The shortfalls range from 0.7% to 22% of the annual guaranteed savings, with the average amount being 6% of the annual guaranteed cost savings. In six of the seven cases, the shortfall was resolved through a reduced payment to the ESCO. In the remaining case — the one in which the 22% shortfall occurred — the M&V report claims that the shortfall was due to an action on the part of the agency and was not the ESCO's

responsibility. Most Super ESPC contracts include a process for dispute resolution, and presumably that process was or is being followed in this case.

It is of interest that for this group of 100 projects, 79.3% of the reported annual cost savings were due to reductions in utility bills, and 20.7% were due to O&M or R&R savings, all of which were stipulated.

For the most part the amounts by which reported cost savings exceeded or fell short of the guarantees were small in relation to the guarantee. This is best seen in a figure, but before presenting it the following description is provided of the way the information is displayed.

Consider a project with annual guaranteed cost savings of $50,000. Before M&V activities are performed, the only information available is the amount of the savings guarantee for this year. This is represented by the left side of Figure 2. Suppose the M&V activities measure a savings of only $40,000, meaning that there is a savings shortfall of $10,000. On the right side of Figure 1, the bar from the left side is shifted downward so that a portion of it falls below the horizontal axis. The amount lying below the horizontal axis is the magnitude of the shortfall, shown in black The amount that remains above the horizontal axis represents the reported savings, shown in light gray. The total height of the bar represents the guaranteed savings of $50,000.

Figure 3 presents another project with a savings guarantee of $50,000 dollars, but where the M&V activities measure a savings greater than $50,000. Here the bar from the left side of the figure is moved upward on the right side of the figure. The bar is shifted upward by the amount of the surplus, which is shown in dark gray. The height of the light gray bar, which represents the guaranteed savings, does not change. The combined height of the bars represents the reported savings.

Using the scheme illustrated in figures 2 and 3, Figure 4 presents the annual cost savings, along with any additional savings or shortfalls, as reported in the most recent available M&V reports for the 100 Super ESPC projects analyzed. The projects are arranged in descending order of reported annual cost savings.

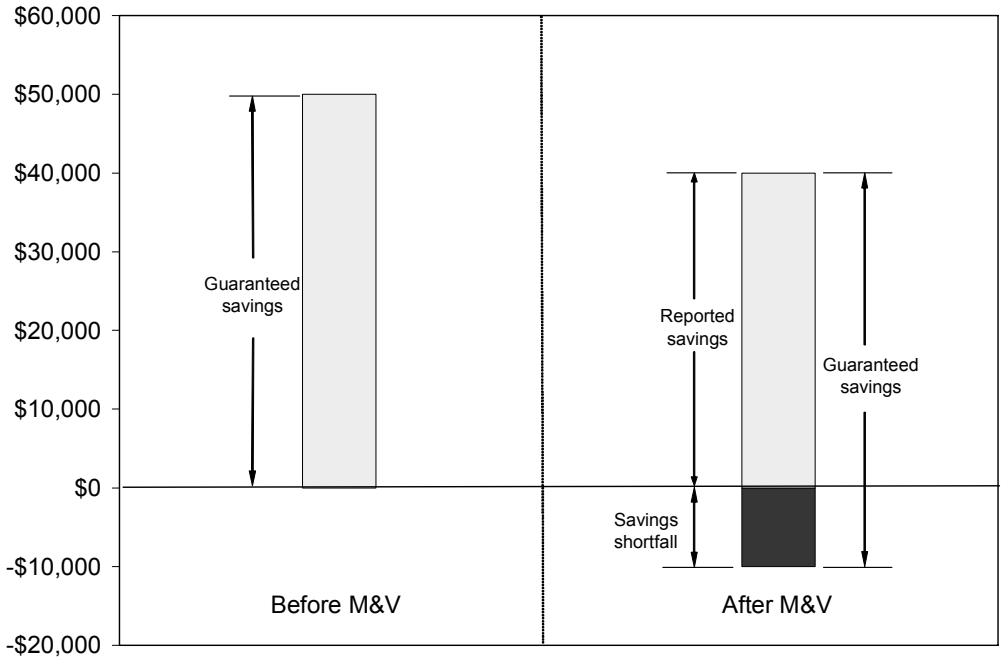

Figure 2: Guaranteed and reported savings for a project with a savings shortfall.

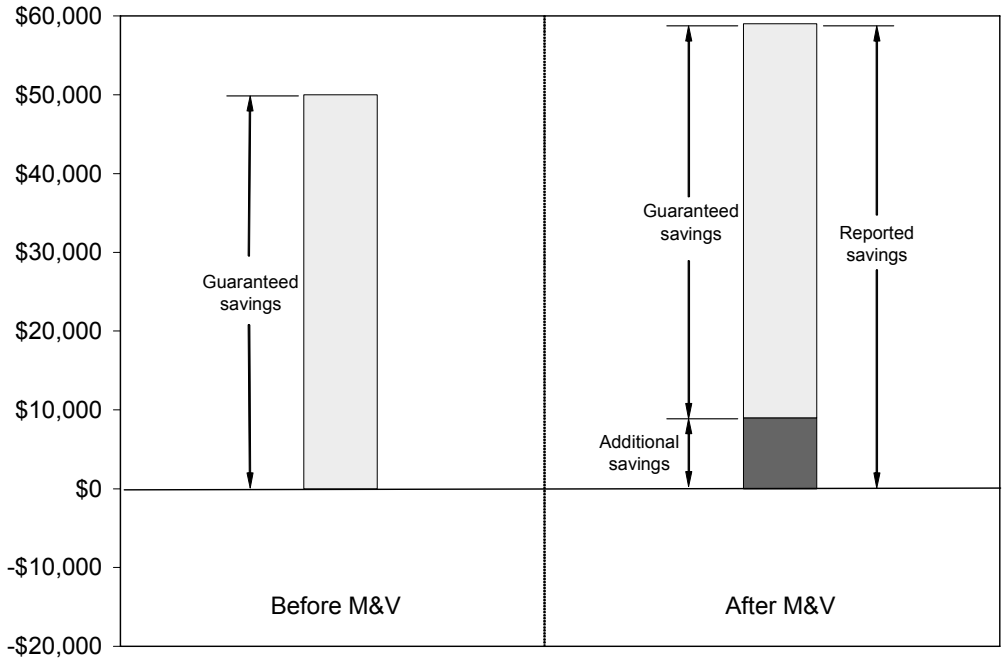

Figure 3: Guaranteed and reported savings for a project in which cost savings exceeds the guarantee.

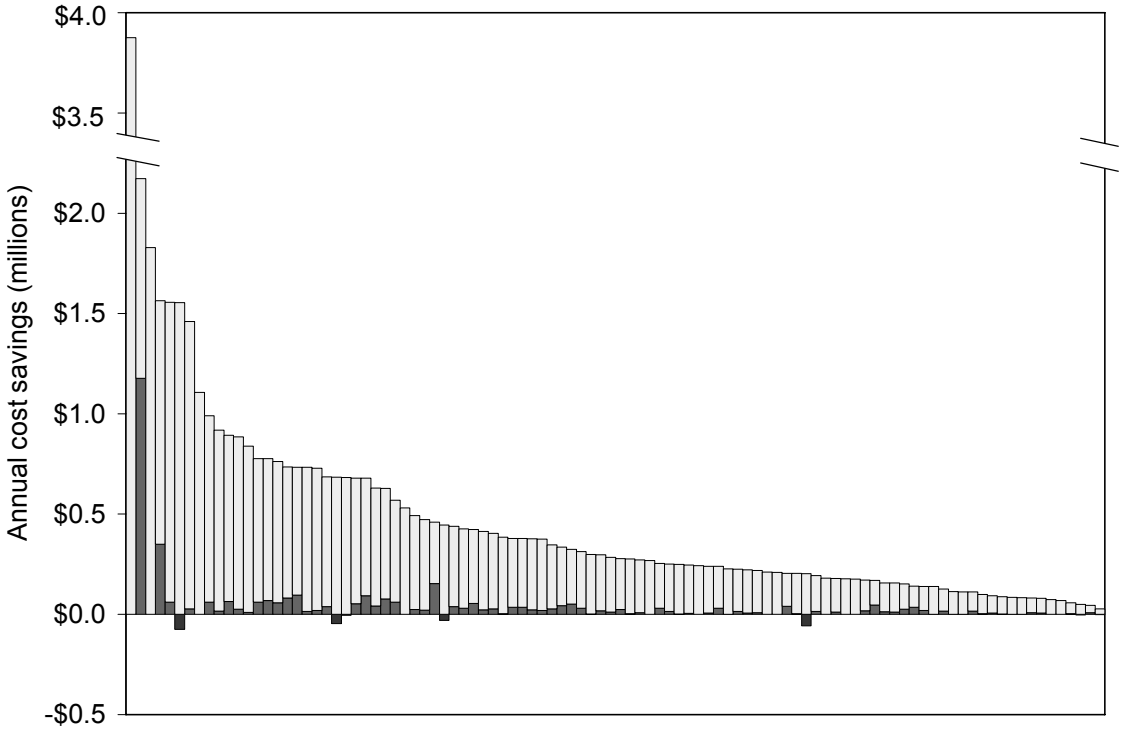

Figure 4: Annual cost savings from 100 ongoing Super ESPC projects. Cost savings above the guarantee are shown in dark gray, cost savings shortfalls are shown in black. Where no shortfall occurs, the light gray bar is the amount of the guarantee. Where a shortfall occurs, the amount of the guarantee is the sum of the heights of the light gray and black bars.

Reported And Estimated Cost Savings

ESCOs use engineering models to estimate project energy savings, and then use contract utility rates and escalation rates to estimate cost savings for each year of the contract. In all, it was only possible to determine estimated and reported cost savings for 91 of the 102 projects. For these 91 projects, the total estimated cost savings for the periods reported on was $45.3 million, and the total reported cost savings was $44.8 million. Thus in the aggregate, reported cost savings were 99% of the estimated cost savings.

The total guaranteed cost savings for the 91 projects was $41.4 million. Note that the $44.8 in reported savings for this group is 108% of the savings guarantee, the same figure obtained for the larger group of 102 projects.

Dividing the estimated savings by the guaranteed savings shows that on average ESCOs guarantee about 91% of the savings they estimate for the reporting period.

Figure 5 shows the amount by which the reported savings exceeded or fell short of the estimated savings in a manner analogous to Figure 4.

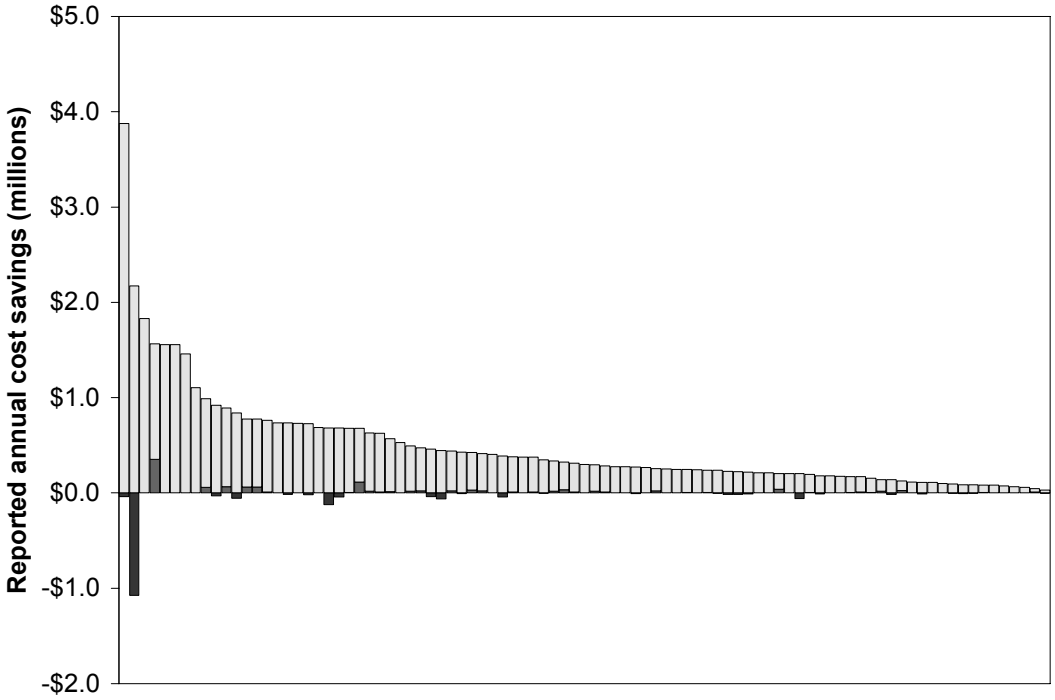

Figure 5: Reported and estimated annual cost savings from 91 Super ESPC projects. Reported cost savings above the estimated amount are shown in dark gray, and reported savings below the estimated amount are shown in black. Where reported cost savings equals or exceeds the estimated, the height of the light gray bar is equal to the estimated savings. Where reported cost savings is less than the estimated amount, the estimated savings is equal to the height of the light gray and black bars combined.

Reported and Estimated Energy Savings

Annual M&V reports track energy savings as well as cost savings, since one of the primary motivations for implementing Super ESPC projects is to meet energy use reduction goals. Energy savings are not guaranteed, but the ESCO estimates the energy savings that will occur in each reporting period and uses those savings to estimate cost savings and to determine the cost savings that will be guaranteed. The annual M&V report usually presents the energy savings realized during the period, as determined by the methods described in the M&V plan. The reported energy savings are used to determine the reported cost savings.

It is customary in the federal government to report energy savings on a site basis, counting electricity savings at 3412 Btu per kWh, and adding in other fuel savings in Btu. This is problematic for energy conservation measures such as combined heat and power plants that offset the purchase of grid electricity by using natural gas, because they can increase the amount of site energy used while reducing the overall amount of energy used at the site and for the power plant to generate the grid electricity used. DOE's guidance on Section 502(e) of Executive Order 13123 was followed in these cases. The guidance credits the site energy use by 8438 Btu for each kWh of avoided electricity use to account for the reduction in source energy use.

Of the 102 annual M&V reports examined, it was possible to determine the reported and estimated energy savings for the reporting period in 95 cases. On a site energy basis, the proposed or estimated energy savings for the 95 projects was 2.918 MMBtu. The reported energy savings was 2.913 million Btu, or 99.8% of the estimated savings. As is true of cost savings, for the most part the amount of energy savings above or below the estimated savings is small compared to the estimated savings.

Energy savings can also be reported on the basis of source energy, which counts the energy used at the power plant to produce grid electricity. Assuming 28.8% electric conversion efficiency, the reported source energy savings resulting from the 95 projects is 5488 MMBtu, compared with estimated source energy savings of 5480 MMBtu. Thus on a source energy basis, reported energy savings is more than 100% of the estimated energy savings — about 100.2%. Since source energy savings correlate directly with reductions in greenhouse gas emissions, this is a more meaningful comparison, and it shows that on the whole Super ESPC projects exceed the energy savings estimated for them.

Conclusions

The evaluation of the Super ESPC program uses a three-tier, nested design (Figure 1), with increasingly more intensive and rigorous methods being applied to smaller and smaller samples. The first tier of the study reviews the latest M&V report for each ongoing Super ESPC project, with the objective of determining estimated, guaranteed, and reported cost savings; and estimated and reported energy savings for the entire population. In Tier 2, savings are recalculated for a stratified subsample of ongoing Super ESPC projects using the methodology specified in the M&V plan. Tier 3 analysis is conducted for a much smaller subsample that meets validity criteria for whole-building or whole-facility data analysis.

Tier 1 of the evaluation has been completed and shows that aggregate reported savings in the Super ESPC program is about 108% of aggregate guaranteed cost savings. Aggregate reported savings is about 99% of the estimated savings. This means that ESCOs are guaranteeing about 91% of the cost savings they estimate for a given period.

Energy savings can be calculated in terms of site energy use and source energy use. Based on site energy use, the projects analyzed reported 99.8% of the energy savings that had been estimated for the periods reported on. Based on source energy use, the projects reported 100.2% of the estimated savings.

While this stage of the evaluation did not attempt to verify the energy or cost savings in any way,

these results do serve as a first-level measure of the overall performance of the Super ESPC program. Based on the information reported, the projects do seem to be meeting their objectives in terms of energy and cost savings.

References

Berry, L.G., M.A. Brown, T. Wright, and D.L. White, 1991. *Experimental Plan for the Single-Family Study,* ORNL/TM-11668/v3, Oak Ridge National Laboratory, Oak Ridge, TN.

Shonder, J. A., and A. Florita**,** 2003. *Energy and Demand Savings from a Geothermal Heat Pump Retrofit Project at Camp Lejeune, North Carolina.*

Shonder, J. A., and P. J. Hughes, 2005. *Seeing Savings from an ESPC Project in Fort Polk's Utility Bills*, ORNL/TM 2004/204. Oak Ridge National Laboratory, February.

U.S. Department of Commerce, 2006. *Energy Price Indices and Discount Factors Life-Cycle Cost Analysis - April 2006*, NISTIR 85-3273-21**.**