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Measurement & Verification Reality Check: A Yawning Gap Between Theory and Practice[1]

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ABSTRACT

The success of an energy efficiency program should be measured in terms of the actual energy savings, and not against "stipulated" or estimated energy savings. Although M&V guidelines and protocols have standardized methods for verifying energy savings accruing from the implementation of an energy efficiency project, M&V is largely viewed as a cost center rather than a value proposition. The jury may still be out on the real value of M&V because it is often perceived as very expensive and too technical. This paper will review measured energy savings data from the Texas LoanSTAR Program and analyze available data and program requirements of Federal and state performance contracting programs that require some level of M&V to verify energy savings. The intent is to determine the role of M&V in different programs and what implications it has on the success or failure of the programs. The paper concludes with suggestions to use M&V as a risk management tool wherein both the service provider and the customer have a vested interest to perform appropriate level of M&V to reduce uncertainty in energy savings in a cost effective manner.

Introduction

Seven years ago, the US Department of Energy (DOE) started a market transformation initiative to help secure low interest loans from financial institutions for energy efficiency investments. DOE envisioned this would be achieved by developing industry consensus and standard methods to measure and verify energy savings resulting from the implementation of energy conservation measures (ECMs). The product, the International Performance Measurement & Verification Protocol (IPMVP), provides standard measurement and verification (M&V) terminology and defines four M&V options to quantify energy and cost savings. It is a savings verification tool with principles that are applicable to commercial and industrial energy efficiency projects. Seven years later, M&V still means different things to different people as it is governed by energy efficiency project objectives, cost, the magnitude of energy savings, the acceptable level of uncertainty in the M&V of energy savings, and the contractural agreement between provider and receiver of energy services.

The success of the IPMVP as a market transformation tool has been well documented (Cowan and Schiller 1997; Kats et al. 1996; Kumar 2000). Standardization of M&V approaches and definitions of common M&V vocabulary have clearly helped an otherwise fragmented energy services industry. The open participatory process in which a broad

[1] Submitted for publication at ACEEE 2002 Summer Study on Energy Efficiency in Buildings.

consensus was sought for all the documents prepared under IPMVP has also helped in obtaining the approval from a wide array of stakeholders from the U.S. and abroad. Even then, the delicate balance between the technical rigor and the flexibility accorded by the M&V options detailed in the latest version of the IPMVP has been hotly debated. Energy services providers point to the high cost of M&V if a rigorous M&V plan that relies heavily on metering must be followed for all ECMs and instead call for a flexible approach. M&V purists, on the other hand, point to the widespread use of stipulated variables (Bradford and Stetz 2001) that are not based on prior measurements or reasonable assumptions leading to large uncertainties in the calculation of energy savings as the major failing of a majority of M&V plans. They argue for tighter definitions of various M&V options and stricter M&V requirements in various programs requiring strict adherence with the protocol.

Objectives

Before we discuss the objectives of the paper, we would like to categorically state that it is not our intent to pass judgement on any program discussed in the paper but rather to understand the M&V requirements of all the major energy efficiency programs and report our findings in an objective manner.

The objectives of the paper can be defined at two levels:

1. **Program level:** The current analysis of energy savings and the associated M&V data from energy efficiency projects is meant to explore the following topics at the program level:
   - Explore the availability of reliable energy efficiency projects data to estimate total energy efficiency investments and energy savings from the following programs:
     - U.S. Department of Energy's Federal Energy Management Program's Super Energy Savings Performance Contracts (ESPC) projects.
     - The US Army and US Air Force indefinite delivery, indefinite quantity (IDIQ) ESPC program.
     - Federal Energy Management Program's Utility Energy Services Contracts (UESC) projects utilizing General Services Administration's areawide contracts and basic ordering agreements.
     - Standard Performance Contracting Programs administered by states such as Texas, California, New York, etc.
     - National Association of Energy Service Companies (NAESCO) database of about 800 energy efficiency projects.
   - Try to better understand the role of M&V in different programs and comment on any discrepancies between the intent and existing practices relating to M&V.
   - Evaluate the elements that determine the cost-effectiveness of an M&V approach under the various programs through a more detailed analysis of the following topics:
     - Main objectives of the program.
     - Main drivers for performing M&V.
     - Trade-offs between reducing uncertainty in energy savings and the cost of M&V.
     - Role of standards such as IPMVP, FEMP M&V Guide, and ASHRAE Guideline 14P (ASHRAE 2000) in preparing a cost-effective M&V plan for different projects.

2. **Project level**: The scope of the current analysis will be limited to the availability of data from the programs listed above. The long-term objective is to refine and update the findings of this analysis by continuing to collect data from other programs and present it at suitable forums. Once we have collected energy savings and M&V data for various programs, a more focused analysis will look at the level of M&V either at the project level or at the individual Energy Conservation Measure (ECM) level. The objectives of the analysis with respect to M&V will be to:
   - Ascertain the level of M&V specific information contained in the various sources of data.
   - Develop or use existing metrics to determine any correlation between the level of M&V and estimated/actual energy savings.
   - Evaluate, where possible, the level and quality of M&V against the level and variability of savings, persistence of savings and benefits from operational improvements (Claridge et al. 1991).

Methodology

Developing a Comparative Framework

Every year, energy efficiency retrofit projects worth millions of dollars are implemented. The first step in conducting any meaningful analysis across various programs is to assemble information from different programs into a common format. To accomplish this task, we set out to collect the following information:

1. At the program level
   - Annual investments (in million $)
   - Annual energy cost savings (in million $)
   - Annual energy savings (in MWh)
2. At the project/ECM level
   - Total retrofit cost
   - Total area of the building
   - Total estimated energy savings
   - Total actual energy savings at project level based on the annual M&V report
   - Total estimated cost savings
   - Total actual cost savings
   - M&V cost
   - Level of M&V
   - Availability of cost and energy savings data at the ECM level

The intent is to develop a framework for "apples to apples" comparison across different programs and, where possible, to evaluate the impact of M&V on the major public programs by comparing the M&V requirements and analyzing the energy savings data. In a phased manner, we want to conduct the analyses that would help answer the following questions:

- Determine capital investment and estimated and actual energy and cost savings under different programs.
- To the extent possible, develop the following metric to evaluate the effectiveness of the program:
  - Determine M&V cost as a percentage of project cost and total savings.

- Any correlation between M&V cost, level of M&V and realization rate (defined as the ratio of actual to estimated savings).
- Return on investments for projects with M&V vs. projects without M&V.

- Start building a database of projects showing ranges of savings for different ECMs along with the M&V options employed, which can then be used to determine cost-effective M&V options. This would require very detailed documentation of energy savings and M&V information at the ECM level across different programs, an unlikely scenario in the near future and definitely outside the scope of the current paper but something that may be very useful for bringing down the cost of M&V.

Analysis

1. US Department of Defense ESPC Program

a) US Army ESPC Program[2]

Program Highlights: The total investment in the program through 2001 is approximately $290 million. The present worth of total projected value of savings is $640 million.

Role of M&V: Although we were not able to get any M&V data to determine the total amount that is being spent on M&V as a percentage of the total project cost, we can throw some light on the M&V requirements. The US Army ESPC program does require project M&V plan to adhere to either IPMVP or the FEMP M&V Guide. Although the ESCOs develop the M&V plan, the US Army requires that the issue of persistence of savings be addressed in the plan and reserves the right to have the M&V plan evaluated by a third-party.

b) US Air Force ESPC Program[3]

Program Highlights: The total term investment in the program through 2001 is approximately $204 million. We were not able to get any other information related to the magnitude of projected energy savings or the cost of doing M&V for the program.

Role of M&V: The US Air Force Civil Engineer Support Agency (AFSECA) has support contracts with 3rd parties to provide technical assistance to Air Force bases in evaluating ESCO's proposals. This will be in the form of a) working with Air Force and the ESCO in developing the M&V plan and would include defining the baseline, specifying commissioning procedures for equipment; b) developing an independent test plan and conducting tests to detrmine actual savings; c) Determine the effectiveness of the existing M&V plan.

[2] Jimmy Haywood's presentation at FEMP M&V Summit in Atlanta (October 2001).
[3] Tatiana Strajnic's presentation at FEMP PF Workshop in Lake Tahoe (February 2001).

2. US Department of Energy Super ESPC Program[4]

Program Highlights: The total investment in the program is approximately $238 million. The total guaranteed cost savings is expected to be approximately $515 million. The energy savings share of this amount is $365 million whereas the remaining $150 million is related to reduction in O&M related costs. Total energy savings are expected to be 4,700 GWh in electricity savings and 9.7 x 10^6 MMBtu in natural gas savings. This is based on an analysis of seventy-six delivery orders that have been signed between various federal agencies and ESCOs under this program. The average implementation price of a delivery order was approximately $3.2 million and the average term of the contract was about 16 years. Average annual M&V cost is approximately 3% of the annual guaranteed cost savings.

Role of M&V: As far as the IDIQ contractual requirement for M&V is concerned, the ESCO is required to perform the following M&V activities:

- Define a site-specific M&V plan, which should specify the M&V Option(s) and methods that will be used for each ECM.
- Define pre-installation baseline energy use and post-installation energy use calculation/verification methods.
- Conduct annual M&V activities to verify operation of the installed equipment /systems and/or calculation of current year's energy savings.

M&V in DOE/DOD ESPCs is important because the Federal agency has an obligation to verify energy savings performance because that forms the basis of the payment to the ESCOs. It also confirms that the government has received contracted annual energy savings. At the same time, it is generally accepted that M&V can be expensive and should be employed in a judicious manner. Developing a cost-effective M&V plan that apportions risk in a reasonable and unambiguous manner is one of the most challenging tasks faced by both ESCOs and the federal agencies. A good M&V plan must always try to minimize the uncertainty associated with energy savings estimates by identifying which variables should be measured and which should be stipulated based on some reasonable assumptions.

The Federal ESPC programs were instituted not very long ago and there is a longer lead time for the first few projects as everybody is on a steep learning curve. Since very few projects have actually been completed so far, it is going to be a while before we have the data needed to answer some of the questions posed at the beginning of this paper. However, the US DOE Super ESPC program collects data to perform a fairly detailed benchmarking exercise that will provide more useful findings in future. Also, the annual M&V reports submitted by the ESCOs to the agencies will be analyzed in the future and that should be very helpful in answering questions related to the impact of M&V on persistence of savings and the effectiveness of the M&V plan in reducing uncertainty in energy savings calculation without being very expensive.

3. NAESCO Database Analysis

Database Highlights: Goldman (Goldman et al. 2000) conducted a study that drew upon a database of 800 projects representing a cumulative investment of $1.4 billion in energy efficiency projects. Although the projects included in this database are not

[4] Terry Sharp's "Super ESPC Program and Pricing Benchmarks" presentation at FEMP Project Facilitator in Estes Park, CO (April 2002).

mutually exclusive of the other programs listed in the paper, it provides interesting insights that will be useful for the current analysis.

There were a total of 794 projects in the database of which 93% are located in the US and the other 7% were in Canada. Only 7% of the total projects belonged to the federal government sector while the share of the state/local government sector was 16%. Roughly 27% of projects belonged to the K-12 schools market. The most frequently listed energy conservation measures were lighting retrofits followed by energy management systems and then came boiler and chiller retrofits. The average cost of the project ranged from $1 million to $2.7 million.

Role of M&V: For each project, ESCOs were asked to report: a) baseline energy consumption (i.e., defined as either baseline energy use that was the basis for savings calculations or pre-retrofit energy consumption); b) predicted energy savings for various end uses; c) guaranteed savings (i.e., the annual energy savings guaranteed by the ESCO as part of a performance contract); d) actual, verified energy savings for applicable energy sources in energy or dollar terms. For verified savings, ESCOs were asked to provide information on energy savings for each year of the contract or calculate the annual average of actual energy savings achieved.

Actual savings, based on the results of post-installation M&V protocols, were within 10% of predicted savings in 47% of the 265 projects that provided this information. The average value for the ratio of actual/predicted electricity savings in this sub-set of projects is 1.16; these results are driven by larger projects. The results suggest that ESCOs typically establish guaranteed savings levels at 80-85% of projected savings for projects. This meant that in virtually all cases for projects in the database, actual verified savings exceeded guaranteed savings.

4. State Performance Contracting Programs

Program Highlights: State performance contracting programs of California, New York, Texas, Colorado, and Wisconsin were analyzed in a study performed two years ago (Schiller et al. 2000). The information presented below is derived from that paper. All the programs were supported by public benefit charge funds. Approximately $400 million of ratepayer funds are expected to be committed for these programs. California, New York and Texas encourage performance-based contracting through standard performance contracting programs whereas Colorado does so through demand-side biding and Wisconsin through contractor support programs. Two main charateristics of these programs are i) incentive payments that are based on documented energy savings for some periods after project installation.; ii) use of private sector energy efficiency service providers as the predominant mechanism for marketing and development of projects. Under California SPC, customers enter into a standard contract with the program administrator in which they receive posted prices for annual energy savings achieved in the areas of heating, ventilation, and air conditioning (HVAC), refrigeration, lighting, and other end uses. Incentive payments are made to participants in three installments, based on demonstrated annual savings over a two-year M&V period. Standard M&V protocols are used to determine the actual savings.

Role of M&V: After pricing, M&V is the most controversial element of performance contracting programs. In contrast to traditional utility DSM rebate programs which typically rely on occasional audits of the installed quantity and cost of measures and

program impact evaluations, performance contracting programs also require M&V procedures to be conducted at the project level. This is because each contractor's payment must be based on that contractor's performance, not the average performance of a group of evaluated contractors. As the origins of these programs are rooted in IRP, DSM bidding, and demonstration of resource savings, they have tended to utilize fairly rigorous M&V requirements that comply with Options B or D of the International Performance Measurement and Verification Protocol (IPMVP 2001).

However, many energy efficiency service providers (EESP) complain that the level of M&V required in these programs exceed what their customers demand. This is aggravated by the fact that a significant number of the contracts between customers and EESPs do not require M&V because they are not performance contracts. This creates a tension between the M&V required in the marketplace between customers and the EESP and the M&V requirements associated with ensuring that public funds are paid only for persistent energy or capacity savings. Customers themselves, when acting as project sponsors, almost always complain about M&V requirements, in part because their prior experience with utility DSM is typically through rebate programs.

Third party contractors are used for M&V of savings from projects in the Colorado DSM Bidding program. This feature can be important if programs target local contractors, who often have less experience with M&V and perceive M&V requirements as a barrier to entry. A specialized M&V contractor may also be able to provide M&V at a lower cost per project because of economies of scale, particularly compared to customer sponsors that might submit only one or two projects.

Advances in M&V standardization should be utilized to improve the manner in which M&V requirements are set and M&V is conducted. The results of prior M&V efforts can also be used to reduce the rigor required of future efforts. For example, in Texas SPC program, deemed savings values are used for common measures; operating hours can be stipulated for lighting efficiency measures, based on the wealth of data associated with prior studies of fixture operating hours. This proper use of deemed savings and stipulations for certain measures would not inappropriately increase the uncertainty of savings from performance contracting programs.

5. Texas LoanSTAR Program

Program Highlights: By 1991, the first year of recorded savings, the program had loaned $17,770,965, it reached a peak of $55,635,428 in 1996, and decreased to an annual funding level of $27,281,071 in 2000. Since 1991 the measured and actual savings for the total program have closely tracked each other, beginning with an annual measured savings of $1,134,357, rising to a peak savings of $11,018,930 in 1997, decreasing to an annual savings of $794,678 in 1999, and rising back to $930,890 in 2000. Total program savings as of January 2002 were $75.7 million in 32 loan sites (298 buildings), $5.6 million in savings from street light retrofits, $4.4 million in savings at K-12 schools, $26.6 in Continuous Commissioning[SM] savings, for a total program savings of $109.2 million[5]. However, hidden within the success of the total program savings is a wealth of

[5] Savings include $3.2 million in savings overlap between retrofit savings and Continuous Commissioning savings.

information that can offer insight into the lessons learned, and most importantly, the value that measured savings and feedback have brought to the program.

Role of M&V: The Texas LoanSTAR program has program level and M&V information dating back to 1991. It has hourly, measured M&V data for most projects although that was generally limited to the building level and not broken down to the ECM level.

The following observations can be made about the LoanSTAR program:

- A fixed metering cost of 3% is allocated to each project. The actual M&V cost is almost always less than the allocated metering cost.
- The M&V level in projects is a subjective measure of the rigor exercised during the M&V process. It would have been more helpful if M&V information were available at the project level broken down by ECMs.
- It is hard to say anything about the specific M&V activities carried out under the program just by looking at the information provided in the table.
- Measured, energy savings information from hourly data is available in an annual format; the data, thus, lends itself to some very useful estimated vs. actual energy savings comparison analysis (Athar et al. 1998).

No trends are immediately observable when we compare the estimated vs. actual energy savings except for the fact that the estimated energy savings can over or under-predict the actual savings. In the attached table, the realization rate has varied from about 45% to almost 300% emphasizing the need for verification of energy savings.

Because the LoanSTAR program has hourly, measured M&V data summarized on an annual basis from 1991 to 2000 it provides a basis to evaluate the impact of M&V on:

- Level and variability of savings.
- Persistence of savings.
- O&M benefits.

Figure 1 below shows the LoanSTAR loan rate, estimated savings and measured savings for the period 1991 through 2000, which were reported by the Energy Systems Laboratory (ESL) in the Annual Energy Consumption Report (AECR) presented to the Texas State Energy Conservation Office (SECO).

In Figure 2, multiyear realization rates for all LoanSTAR buildings are shown from 1991 to 2000, which range from –100% to +300% for individual buildings. The annual program average displayed as a solid line, which began at 114% in 1991, rose to a peak of 121% in 1994, dropped to a low of 63% in 1998 and rose back to 85% in 2000.

In Figure 3, the actual savings (x-axis) are plotted against the estimated savings (y-axis) using a line to connect the points to show the behavior of the loan over time. This figure has helped to verify several features of interest. First, very few individual sites cluster around the diagonal line, which would represent complete agreement between estimated and actual savings. Sites that have a horizontal line represent sites where the estimated savings remained the same, but the actual savings varied over the life of the loan. This is in contrast to sites that have a vertical line, which represents sites where the actual savings remained the same, but information was discovered about the estimated savings that caused the value of the loan to change. Sites with varying diagonal lines contain a combination of changes to the actual and estimated savings. Several sites actually zig-zag back and forth indicating both positive and negative changes to either the estimated or actual savings – clearly a testament to the value of accurate measured savings.

Figure 1: Multi-year Loan Rate and Estimated/Actual Savings for LoanSTAR buildings (1991 – 2000).

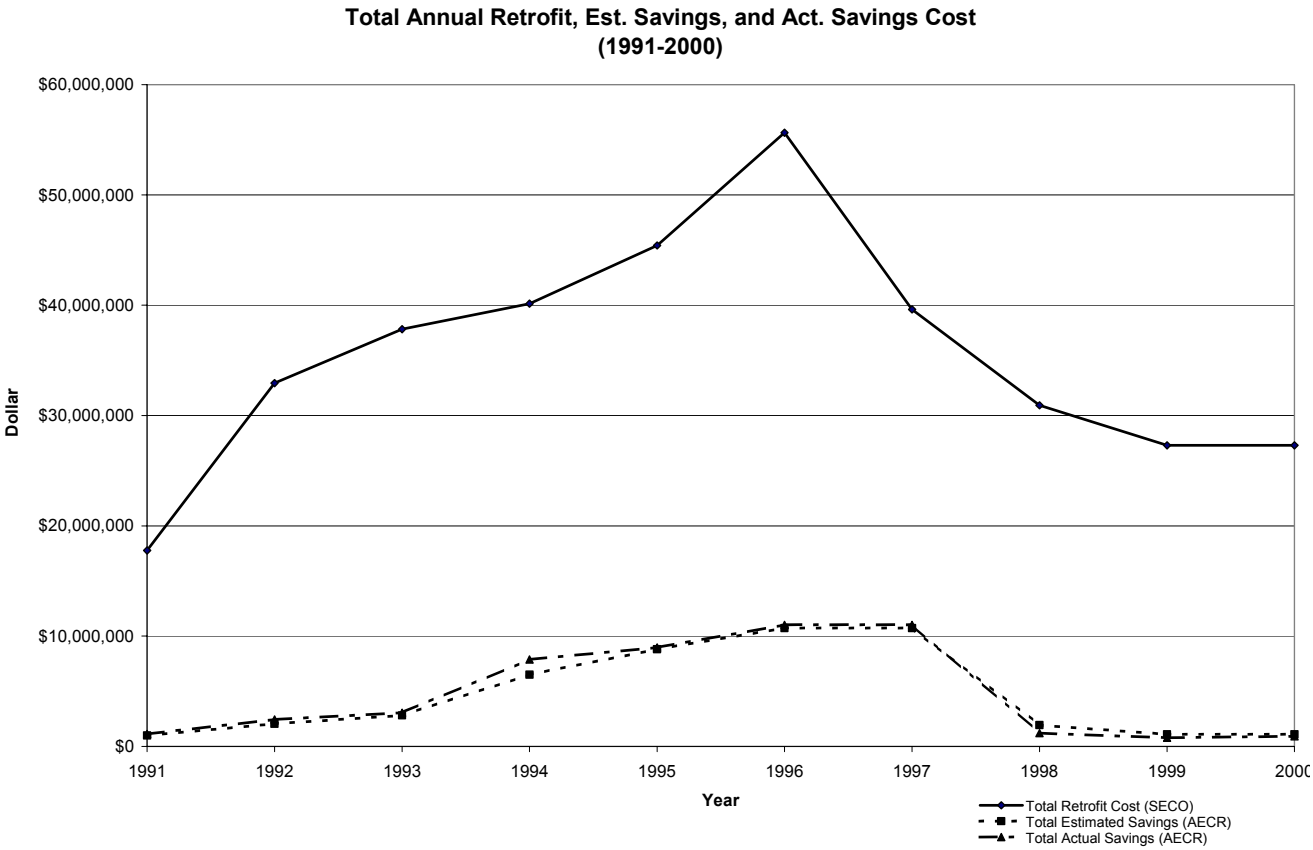


Figure 2: Multi-year Realization rate for LoanSTAR buildings (building data: 1991 – 2000).

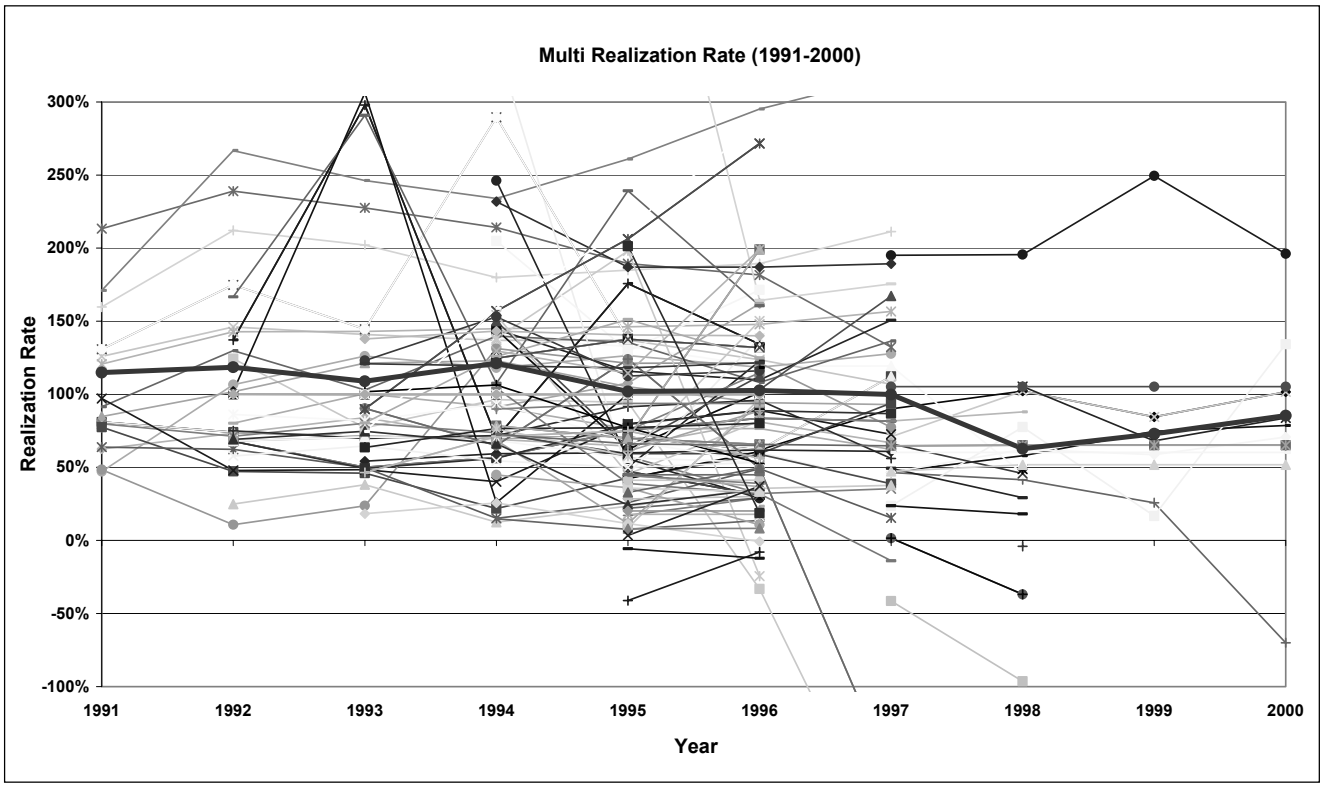
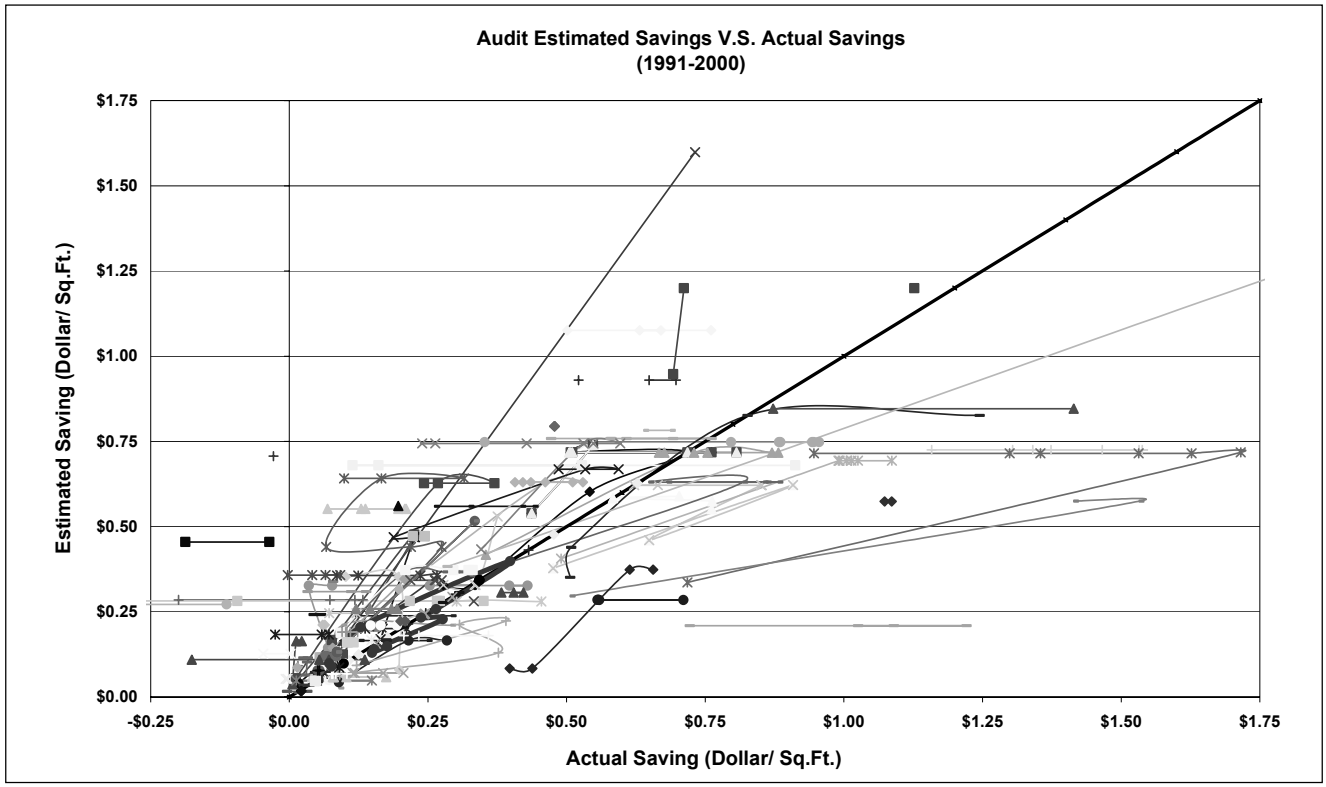


Figure 3: Multi-year Realization rate for LoanSTAR buildings (profiles: 1991 – 2000)



Conclusions

The comparative analysis, which was the initial goal of the paper, was stymied by the absence of M&V data in all except the Texas LoanSTAR program. While there are many energy efficiency programs with a cumulative investment of more than a billion dollars, which have stringent M&V requirements, the level of M&V that is actually performed is always determined by the agreement between the ESCO and the customer. We hope that the Federal ESPC programs will provide a wealth of information as more projects are completed and annual M&V reports comparing the estimated versus actual energy savings are submitted. It should be pointed out that the estimated versus actual energy savings information will only be useful if the actual energy savings numbers are verified based on the measurement of those performance and operational parameters that are highly variable in nature. While proper use of stipulation can help reduce M&V cost without significantly increasing the uncertainty in energy savings calculations, improper use of stipulation will always introduce large uncertainties in calculations thereby putting at risk the entire project.

The analysis conducted for the Texas LoanSTAR program for year 1995 through 2000 yielded the following conclusions:

- Preliminary analysis shows that the sites with utility bill tracking only showed up to 70% savings whereas the sites with hourly measured data produced 100 – 110% savings and

M&V with hourly data and a carefully administered commissioning program can produce 120 – 150% of audit retrofit savings reinforcing the results from earlier studies (Claridge et al. 1994; Claridge et al. 1996; Kats et al. 1996).

- In the case of the LoanSTAR program, if savings cannot be verified, then the loan period is sometimes extended. This may not be a viable option in ESPC although the exact manner in which the dispute may be resolved will be dependent on individual contracts.
- In several of the LoanSTAR buildings, a lack of savings in the first few years resulted in investigations that found the reason, fixed it and subsequently improved savings. This occurred in the University Teaching Center and P.C. Library buildings, for example.
- In several buildings savings decreased and more detailed analysis is required to find out the exact reasons for that.

Based on our analysis of various programs, we have the following recommendations:

- There is a dire need to document energy savings (estimated and actual) in projects that require some sort of measurement and verification.
- Efforts should be directed towards reducing monitoring and verification costs, not reducing the quality of M&V itself.
- Cost-effective M&V methods that are appropriate and rigorous should be developed to reduce uncertainty in energy savings estimates. Characteristics of specific energy conservation measures and of the entire energy efficiency project must be taken into account while developing the M&V plan.
- Facility managers and energy service providers should be working towards using data collected during M&V to improve O&M and/or commissioning.
- There should be a dialog between the M&V professionals and EMCS systems manufacturer to enhance the capabilities of EMCS systems so that more M&V can be performed by these systems.

The real value of M&V is in identifying the risk elements such as degradation in performance of equipment, change in usage pattern of the facility, weather, utility rate change, etc. and their impact on the projected energy savings. Assigning responsibility of any uncertainty associated with these risk elements to one of the two parties would go a long way in developing an M&V plan that will help minimize the risk for both ESCOs and customers.

References

[ASHRAE], American Society of Heating, Refrigeration and Air Conditioning Engineers. 2000. “Proposed Guideline 14P - Measurement of Energy and Demand Savings.” Atlanta, GA.: American Society of Heating, Refrigeration and Air Conditioning Engineers.

Athar A., M. Abbas, J. Haberl, D. Turner, D. Claridge, and T. Harvey. 1998. “Environmental Impact of the Texas LoanSTAR Program.” *In Proceedings of the Eleventh Symposium on Improving Building Systems in Hot and Humid Climates*. Ft. Worth, TX.: Texas Building Energy Institute.

Bradford Jim, and Mark Stetz. 2000. “Stipulated Energy Savings for Performance Contracts.” *E Source* ER-01-3. Boulder, CO.: Platts, Division of McGraw-Hill Companies.

Claridge David E., Jeff S. Haberl, M. Liu, J. Houcek, and A. Aathar. 1994. "Can you Achieve 150% of Predicted Retrofit Savings? Is it Time for Recommissioning?," *In Proceedings of the ACEEE 1994 Summer Study on Energy Efficiency in Buildings*, 5:73-88. Washington, DC.: American Council for an Energy-Efficient Economy.

Claridge David E., Jeff S. Haberl, D. O'Neal, W. Heffington, D. Turner, C. Tombari, M. Roberts, and S. Jaeger. 1991. "Improving Energy Conservation Retrofits with Measured Results." *ASHRAE Journal*, 33: 14-22.

Claridge David E., M. Liu, Y. Zhu, M. Abbas, A. Athar, and Jeff S. Haberl. 1996. "Can you Achieve 150% of Predicted Retrofit Savings? Revisited." *In Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings,* 4:31-48. Washington, DC.: American Council for an Energy-Efficient Economy.

Cowan John D., and Steven Schiller. 1997. "Measuring Energy Savings for Modernization Projects." *ASHRAE Journal*, 39: 60-62.

Goldman C. A., P. Juergens, M. Fowlie, J. Osborn, K. Kawamoto, and T. Singer. 2000. "Historical Performance of the U.S. ESCO Industry: Results from the NAESCO Project Database." *In Proceedings of the ACEEE 2000 Summer Study on Energy Efficiency in Buildings,* 5:89-101. Washington, DC.: American Council for an Energy-Efficient Economy.

[IPMVP] International Performance Measurement & Verification Protocol Technical Committee. 2001. "Concepts and Options for Determining Energy and Water Savings. " Washington, DC.: US Department of Energy.

Kats Gregory H., Arthur H. Rosenfeld, Tim A. McIntosh, and Scott McGaraghan. 1996. "Energy Efficiency as a Commodity: The Emergence of an Efficiency Secondary Market for Savings in Commercial Buildings." *In Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings,* 5:111:122. Washington, DC.: American Council for an Energy-Efficient Economy.

Kumar Satish. 2000. "Measurement and Verification of Energy Savings." Available Online: http://www.energyusernews.com/eun/cda/articleinformation/features/bnp__features__item/0,2584,16252,00.html. *Energy User News*.

Schiller S., C. A. Goldman, and B. Henderson. 2000. "Public Benefit Charge Funded Performance Contracting Programs - Survey and Guidelines." *In Proceedings of the ACEEE 2000 Summer Study on Energy Efficiency in Buildings,* 5:299-317. Washington, DC.: American Council for an Energy-Efficient Economy.