A PILOT CASE STUDY OF MEASUREMENT AND VERIFICATION FOR A MAJOR TEXAS STATE AGENCY PERFORMANCE CONTRACTING INITIATIVE

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ABSTRACT

In 2003 the Texas Mental Health and Mental Retardation agency, now consolidated into the Texas Health and Human Services Commission, was challenged to deal with continuously deteriorating infrastructure at twenty-three large campuses located throughout the state during large statewide budget cuts. Funding was significantly reduced with costs for repair and replacements amounting to more than $250 million. In response, the agency decided to capitalize on new state legislation that was passed in 2001. This legislation authorizes state agencies to make use of utility performance contracting by using the utility savings to pay for the more efficient equipment cost over a fifteen-year period.

The savings will be measured and verified over the life of the contract in order to maintain the savings guarantee. The energy services firm that the agency chose to implement the utility savings contract employs a utility bill analysis software tool based on cooling degree-days and heating degree-days [1]. This paper compares the contractor's software [2] savings results to savings results from a regression analysis software package using average outdoor air temperature data and actual pre- and post-retrofit data on representative meters at the Austin State Hospital located in Austin, Texas. The software that is being used as the comparison calculates simple mean, two-parameter (2P), three-parameter (3P) change point, or four-parameter (4P) change point models to be used as the utility baseline. To accurately account for the guaranteed savings, it is imperative to apply detailed as well as practical measurement and verification techniques. The agency works closely with the ESCO to generate a savings persistence program that both parties can effectively put into practice; thus ensuring long-term goals are met.

INTRODUCTION

The 77th Texas Legislative Session passed a statute in 2001, which was signed into law by the Governor of the State of Texas, charging State Agencies to attain all cost effective energy and water efficiency measures that were possible within a fifteen year period. The Texas Department of Mental Health and Mental Retardation (TDMHMR) agency, now consolidated into the Texas Health and Human Services Commission (HHSC), entered into an energy savings performance contract (ESPC) to adhere to the legislation and meet immediate repair and replacement needs. The initiative began in November of 2002 when the agency issued a Letter of Interest to receive responses from potential performance contracting companies. All contractors that qualified for the short list of requirements were asked to submit a Response for Qualifications, which underwent a thorough review of each company by a selection committee. Based on the results of this selection process, the agency selected the energy services company (ESCO) that scored the highest in the selection categories. After selection, this ESCO examined all potential utility savings opportunities to implement the recommendations at 23 agency campuses located across Texas.

The ESCO first performed a preliminary utility audit survey of 23 campuses that consist of 10 mental health facilities and 13 mental retardation facilities with approximately 1,400 buildings throughout the state at no up-front cost to the agency. These facilities operate with a 24-hour per day, 7-day per week schedule for full-service care to clients with mental illness and mental retardation conditions. After visiting each site and performing a basic analysis of utility savings opportunities, the ESCO divided the sites by region into five phases to do a more detailed utility audit of each facility. The preliminary utility audit indicated that approximately $52.3 million in energy and water improvements could be supported from savings. The scope of work included facility improvements for more than $31.4 million in immediate repair and replacement needs, which would be paid from savings. When complete, the project should exceed $4 million per year in savings, or approximately 20% of the current utility budget. For the agency to repay the loan, the ESCO will guarantee the utility savings for fifteen years at the baseline utility rates.

The agency worked closely with the ESCO in all the relevant segments of the project stages. This level of work is crucial to realize the objective of providing the state taxpayers and agency clients with the most value possible. Since both parties are committed to working as a team to make this project the best it can be, more overall value can be achieved in less time. During this utility audit, many discussions took place to decide on the most practical methods that could be performed cost-effectively. These types of projects, if not implemented properly, have a history of producing poor results since savings tend to degrade over time. Therefore, the agency was determined to turn the process into a successful model that other state agencies may follow while simultaneously minimizing risk to the agency. One step the agency took was to consult with the Energy Systems Laboratory (ESL) of Texas A&M University, a State of Texas agency acting on behalf of the HHSC as the owner's representative. The ESL assisted in the development of the Measurement and Verification (M&V) strategy to ensure that the savings will indeed occur. As the owner's representative, the ESL was also involved in reviewing savings calculations and construction/retrofit oversight. This not only helped the agency ensure that the project is implemented properly, but also helped the agency adhere to state requirements of an additional independent third party advocate.

PROJECT SCOPE

During Phase One, several utility savings opportunities were analyzed and recommended. These consist of energy efficient lighting, higher efficiency chillers, energy management and control systems, window films, low-flow faucets/showerheads, and low-flow toilets since most of the agency's campuses do not have a control system in-place and this project will provide significant savings potential. The control system will also improve the level of comfort for the agency's clients and employees as well as greatly reduce the number of hot and cold calls that number into the hundreds per year. With the lighting upgrade, lighting quality will also improve and benefit those clients with vision impairments.

It was also determined that significant savings opportunities can be achieved by decommissioning steam plants and loops. Individual building water heaters will be installed in the buildings originally served by the utility loop. This part of the scope is especially significant to the agency due to the substantial maintenance requirements, workplace risks, and wasted energy from the steam losses with the installed obsolete systems. A typical steam loop was estimated to be less than 50% efficient in delivering steam to the point of use versus an estimated efficiency of 80% with dedicated heating water systems.

The ESPC project was divided into five phases that embody typical ESPC opportunities such as those described for Phase One. Phase One with five campuses will cost $13.9 million and will provide the agency with approximately $1.47 million in annual savings once completely implemented. Phase Two, currently at the 50% stage of implementation, has work being performed at five additional sites at a total cost of $11.5 million and will generate $1.24 million in annual savings. Phase Three recently began its implementation portion at five more sites and will save approximately $1.4 million annually at a cost of $13.1 million. Phase Three will be followed by Phases Four and Five. An additional phase, Phase Six, was added shortly after Phase One and includes consolidating laundry facilities into centralized sites by utilizing more efficient large Continuous Batch Washers (CBW) instead of many low efficiency washers. The ESCO performed a preliminary study and determined that this project could pay for itself as a stand-alone phase through electric, natural gas, and water savings. The CBWs are automated washers that recycle significant amounts of water, thus saving water and energy to heat the water. The cost of this phase was $5.2 million and will save approximately $580,000 annually now that it is fully implemented.

Financing for the ESPC is facilitated by a combination of the Texas Public Finance Authority (TPFA) and the Texas LoanSTAR Program. The agency will use TPFA's Master Lease Purchase Program, which offers a variable interest rate of 3-5% and is financed over fifteen years. The second funding source is provided through the Texas State Energy Conservation Office's (SECO) LoanSTAR program with a 3% interest rate over a ten year period. This is a revolving loan fund for public sector energy efficiency projects in Texas.

MEASUREMENT & VERIFICATION MODEL ANALYSIS

One of the most important components of a performance contract entails a good M&V approach to account for savings. Since the agency and the ESCO are dependent on each other to make the project a success, a good working relationship is significant. The agency must ensure that adequate savings accrue to fund the project's total debt service. The ESCO needs to make sure that enough savings are produced to meet or exceed the savings guarantee so that the company will not be forced to cover any shortfall. Long-term M&V is therefore necessary to oversee utility usage to guarantee that savings do not fall short when savings degradation occurs by quickly correcting deficiencies in operations or equipment quickly. Two M&V protocols were used with this project to set the requirements for calculating utility savings, the International Performance Measurement and Verification Protocol, [3] and ASHRAE Guideline 14-2002 [4]. Both the ESCO and the owner's teams needed to agree on the M&V process. The M&V needs to be cost effective, assure that saving continue to be met and provide acceptable measurements for determining if savings fail to be met.

One significant and costly error that many owners make involves deciding to discontinue the M&V contract with the ESCO after two or three years. Owners typically make this decision because they mistakenly believe that once the savings have been established and the first or second year savings guarantee is met, savings will consistently continue for the duration of the debt service term. This misguided belief has created unhappy customers when savings decline in years three and beyond. Although very dependent on the energy savings measure, declining savings occur for a variety of reasons. A common reason involves poorly trained operators resetting or readjusting optimally adjusted controls, which can cause energy consumption to increase. A study on persistence by Claridge et al. [5] shows that savings decrease between 10% and 30% per year without effective M&V. If no M&V analysis exists to keep "savings loss creep" in check, the true scale of the problem can remain hidden from normal accounting methods. Additional M&V guidance can be found at the US Air Force web page [6] for specific retrofits.

For Phase One, the annual M&V cost is $135,625, which amounts to approximately 9% of the projected annual savings. This service includes quarterly savings reports, an annual savings report, and regular site visits by ESCO personnel to continuously monitor site utility consumption and troubleshoot any problems to ensure that the savings are met. It also includes periodic re-training to keep site personnel up-to-date with operations and maintenance procedures and issues. Since savings have previously been shown to decrease between 10% and 30%, the annual M&V cost is a worthwhile effort. Therefore, the cost of savings persistence should be viewed as an investment in maintaining the savings rather than an expense and the cost should be fully borne by the project. It should also be noted that many energy services companies reserve the right to discontinue the savings guarantee if the owner cancels the M&V contract.

From the ESCO's perspective a good quality M&V program will pay dividends over the long-term. The primary reason an ESCO should pursue a good M&V strategy is to avoid having to unnecessarily fulfill its guarantee with a check to the customer in order to compensate for a savings shortfall. Another excellent motivation is to stand out as a premier ESCO in the industry with a competitive edge by building a reputation for quality work that is fair and equitable to both parties. Without effective M&V, customers can be left in an unfortunate financial situation when a vendor does not provide high quality work, a good method of accounting and the necessary follow up to sustain the savings. For large customers, having an in-house energy management team is imperative to manage large projects. If inside staff cannot be made available, a competent outside consultant should be considered. HHSC is successfully utilizing both avenues to manage this project.

By working together over a period that spanned approximately nine months, the agency and the ESCO developed an extensive plan to utilize Option C, before-after retrofit savings of the International Measurement and Verification Protocol (IPMVP) on a whole-building utility meter level. Since this ESCO had extensive experience with a popular M&V accounting package, which contains a whole-building statistical modeling capability, this was determined to be an appropriate tool to use for the project M&V. The agency and the Energy Systems Laboratory performed several independent side-by-side comparisons of the software against ASHRAE's Inverse Model Toolkit (IMT) in order to be more comfortable with the long-term results. The weather data, containing daily high and low temperatures, was obtained from the National Weather Service nearest to the site to perform weather normalization analysis. Utility bill whole-meter electricity and natural gas consumption data were modeled versus the average of daily high and low temperature data to obtain weather-normalized models. After verification, the agency agreed to use the weather-normalized models as the baseline models. The ESCO was then directed to use either two or three twelve-month sets of data in order to obtain an improved model. When more than twelve months of data were not available, a one-year dataset was deemed to be sufficient. Smaller meters such as parking lot lighting meters were not used in the analysis.

The Detailed Utility Audit and M&V Plan contains information that includes which IPMVP measurement method is used, the baseline models that were developed, the allowed adjustments and how they will be dealt with over time, and the determination of the utility cost saved. The audit involved technical expert site visits to survey all the buildings, equipment, layout and conduct interviews. The team measured certain pieces of major equipment for savings calculations, collected utility bills and obtained copies of as-built drawings and building schedules.

A full accounting of all the guaranteed meters was completed with detailed documentation of the utility rates and riders that are in place at the time of implementation so that the savings can readily be recalculated independent of the ESCO. In addition to accounting for all the meters, each meter was audited for billing accuracy by recalculating the bill on a spreadsheet using the rate structure obtained from the utility company. This not only established whether the proper amount was charged, but also ensured that the baseline data is correct going forward. The ESCO submitted electronic files, which included the weather data used during the baseline period and all regression model input files for independent verification.

Because this is a long-term project, which will be carried out over fifteen years, the agency was adamant about meticulously detailing every aspect of the project. All involved recognized that personnel on both sides of the project will ultimately change over time; thus the need for thorough documentation that can be easily comprehended by anyone who takes on the role of managing this project in the future. By working together, the agency and the ESCO developed documentation that is not normally included in Detailed Utility Audit Reports and M&V Plans.

An important part of detailed M&V includes basic metrics that can help identify possible problem areas by simply comparing relative magnitudes of similar retrofit recommendations. These relative magnitudes can be side-by-side percentage comparisons of site energy use and energy efficiency measure, and savings for each. Another metric used in this project that can spot an abnormality is a utility percent reduction that shows how much of the overall utility meter is being proposed for savings. On various occasions, these tools proved invaluable in rooting out problems before the project was finalized and an implementation contract signed.

M&V METHOD COMPARISON

The ESCO used a degree-day method incorporating a variable-based degree-day. One of the issues with variable-based degree-day methods involves not being able to clearly visualize the energy consumption over the entire range of outdoor temperatures. Therefore, these data were verified independently using the methods in ASHRAE's Inverse Model Toolkit (IMT). This was possible because the electric and weather data had been collected and provided to the agency as part of the requirements of the contract.

The data consisted of the daily average outside temperature for Austin and the monthly consumption data from the utility bills. The daily temperature data covered July 1, 2000 through January 31, 2006, allowing the average temperature to be matched to the days in each billing period. The baseline spanned 3 years from January 3, 2001 through, January 2, 2004. The baseline modeling included a simple mean value, a linear regression (2P model), a 3P model and a 4P model. The data analysis involved normalizing the monthly utility bill to obtain the average consumption per day for each of the months in the baseline. Next, the model was determined and then the total energy was determined by calculating the consumption per month and per year.

Figures 1 through 4 show the results of the four models that were calculated with the Inverse Model Toolkit illustrating the consumption compared to the outdoor average monthly temperature.

The equations for each model are listed below and use the following acronyms (OAT – Outside Temperature, CP – Change Point):

Note that the Mean yielded the highest discrepancy from other methods and would not be recommended for use in any analysis of savings.

Mean: E = 2790.9698 kWh/day as shown in Figure 1.

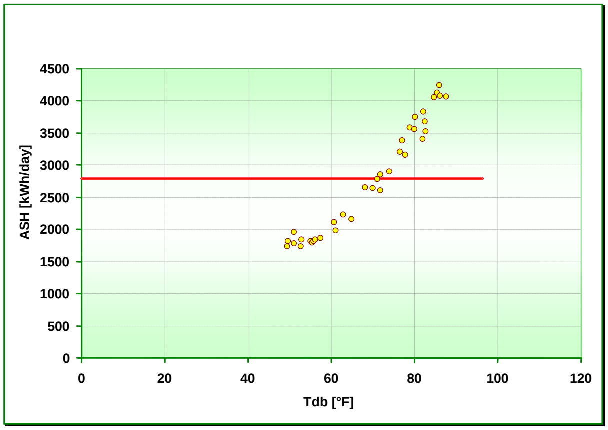

Figure 1. Simple Mean Value

2P: E = (66.6639*(OAT) – 1826.4315) kWh/day as shown in Figure 2.

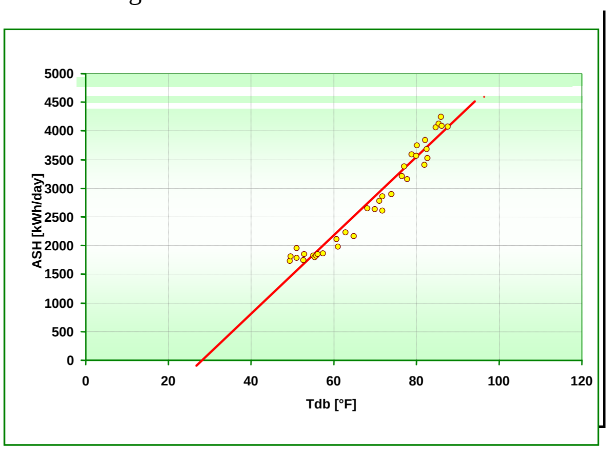

Figure 2. 2P Model (Linear Regression)

3P: For E<CP
E = 1816.1851 kWh/day
3P: For E>CP
E = 82.9289*(OAT – 59.3) + 1916.1851 kWh/day
as shown in Figure 3.

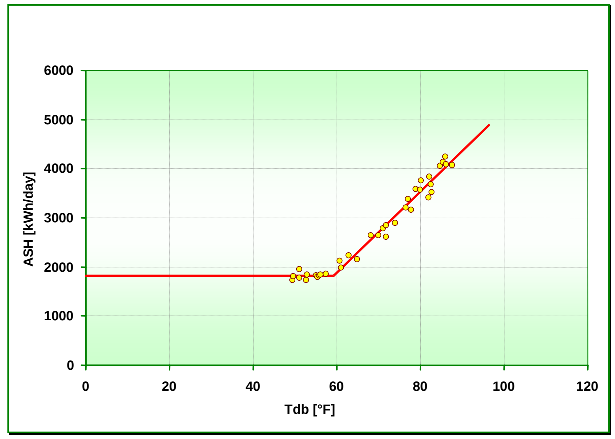

Figure 3. 3P Model (Showing Change Point)

4P: For E<CP
E = 25.6453*(OAT) + 463.6706 kWh/day
4P: For E>CP
E = 88.5103*(OAT – 63.9) + 2102.9811 kWh/day
as shown in Figure 4.

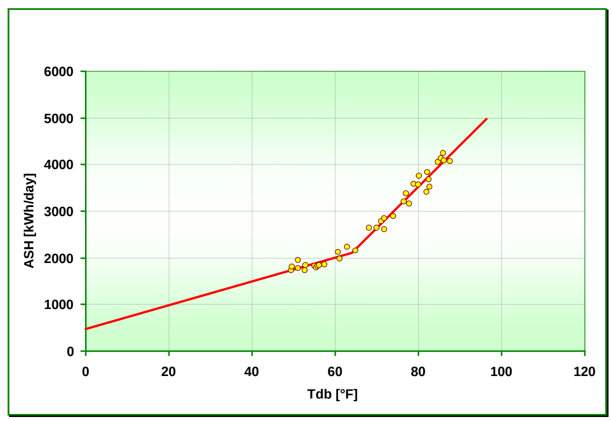

Figure 4. 4P Model (Showing Change Point)

The first year of operation spanned December 1, 2004 through November 29, 2005. The post-retrofit billing data was then normalized to obtain the average daily consumption for each of the 12 months. The weather data were then used to determine what the costs would have been if the retrofits had not been applied and the weather matched to December 2004 through November 2005. The savings then becomes the difference between what the cost would have been and the actual bills for each of the monthly billing periods. Table 1 shows the results, which over the year, agreed with the calculations performed by the ESCO. The comparison savings are shown for 1P, 2P, 3P, and 4P for the data calculated by IMT on a kWh per month level. Note that the agreement improves with more sophisticated models, i.e., 3P and 4P. The ESCO achieved the guaranteed savings over the one-year period when any of these more sophisticated approaches were used.

	Vendor Calculation	Agency Calculations				
	Savings	1P	2P	3P	4P	
Jan	11,939	54,686	20,123	21,543	22,655	kWh/Mth
Feb	13,820	37,575	6,684	10,281	10,263	kWh/Mth
Mar	14,156	30,691	5,566	3,397	5,598	kWh/Mth
Apr	13,965	29,900	11,571	2,348	5,217	kWh/Mth
May	20,913	3,776	1,101	-3,561	-5,532	kWh/Mth
Jun	29,083	4,740	15,626	13,381	12,156	kWh/Mth
Jul	29,266	-20,299	5,841	8,061	8,437	kWh/Mth
Aug	28,345	-9,500	22,771	26,190	26,950	kWh/Mth
Sep	35,223	1,495	36,913	40,654	41,483	kWh/Mth
Oct	17,712	29,579	60,617	63,735	64,391	kWh/Mth
Nov	18,891	28,053	32,443	29,208	27,698	kWh/Mth
Dec	15,305	44,489	36,026	29,210	26,430	kWh/Mth
Total	248,618	235,186	255,281	244,447	245,745	kWh/yr
% Deviation		5.4%	-2.7%	1.7%	1.2%	

Table 1. Electrical Savings Comparison

CURRENT STATUS

Construction of the first phase is nearing completion with some results now available. The electrical savings for the fourteen months during construction amount to $172,000. The total construction term guarantee, including electrical, natural gas, water, chemical, and laundry savings is $475,000.

Determining savings based on measurement has a high priority with the agency since the first debt service repayment came due requiring proof that savings did indeed occur. The savings will continue to be measured and verified over the life of the contract in order to maintain the savings guarantee. Since the ESCO has responsibility for using measurements to calculate the savings over the life of the project, a separate analysis will be randomly used to verify the ESCO's savings report.

The agency will continue to work closely with the ESCO to verify that the savings persists throughout the life of this project. By receiving quarterly and annual reports, the agency can easily verify that the savings are achieved. The reports show utility usage and costs for each Phase One site compared to the baseline usage. Savings are reported per site, month, quarter, and according to project phase.

In Figure 5, cumulative savings are summarized for the most recent data available showing the savings of each utility component for Phase One sites. The annual guarantee is also shown for reference. Figure 5 also compares the savings to the annual guarantee level and divides the savings into its electric, natural gas and water components. The stipulated part, or approximately 2% of the total savings, is achieved by eliminating the use of boiler chemicals at the steam plant that was decommissioned and changing to a more favorable electric rate schedule at one of the five sites. Phase One also included a CBW project at one of the five sites that is not included in the CBW project of Phase Six. The figure shows that the savings accumulated during the construction period exceeded the guarantee and the savings goal. By agreement, the agency retains all savings in excess of the guarantee for both the construction period and after. Figure 6 shows a more detailed view of the data in Figure 5 with fourteen months of accumulated savings data versus the guarantee.

SUMMARY

This paper compared the savings results from the ESCO's software to a regression analysis software package using average outdoor air temperature data and actual pre- and post-retrofit data on a representative meter at the Austin State Hospital. The software that used as the comparison calculates the simple mean value, 2P, 3P change point, and 4P change point models to determine the utility baseline.

After comparing the savings calculated by the ESCO with an independent measurement and verification modeling toolkit, HHSC is more confident that the savings will occur as guaranteed. Four different models were calculated for the same electric dataset from the Austin State Hospital. The agency was initially concerned that the savings would not be correctly calculated. In this case, three of the four models, the 2P, the 3P, and the 4P matched the ESCO's data closely with the 1P dataset still falling within reasonable tolerances over one full year. Additional analysis will be performed on a selection of data as they become available to assure that savings occur and are calculated correctly.

These types of inspections will be performed independently throughout the life of the guarantee period to ensure that the savings will be consistent. This approach forms part of a prudent savings program that the agency has adopted in order to successfully implement the scope that was initially established. The taxpayers of the State of Texas along with the HHSC clients will be well served by consistent follow-through with this program.

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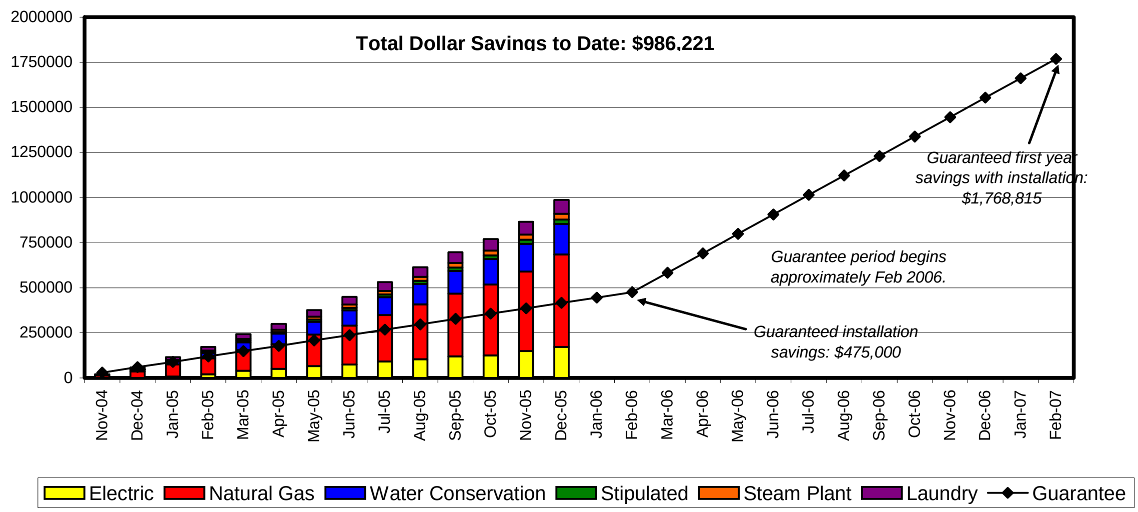

Figure 5. Cumulative Savings versus Guarantee

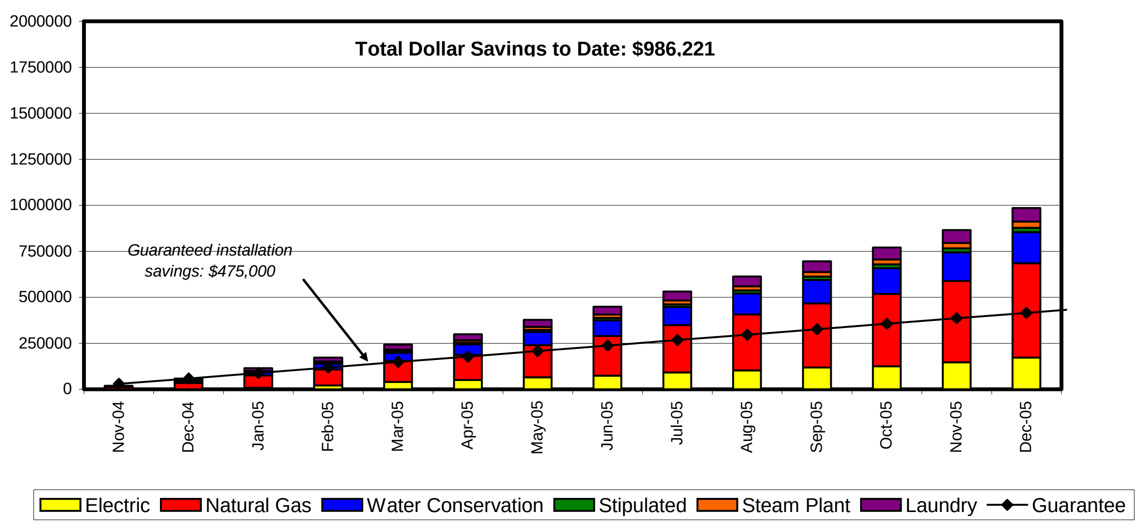

Figure 6. Cumulative Savings versus Guarantee