SUSTAINING LONG-TERM ENERGY SAVINGS FOR A MAJOR TEXAS STATE AGENCY PERFORMANCE CONTRACTING INITIATIVE

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ABSTRACT

The Texas Mental Health and Mental Retardation agency, now part of the Texas Health and Human Services Commission, was challenged to deal with regularly deteriorating infrastructure at twenty-three large campuses located throughout the state during large statewide budget cuts in 2003. Repair and replacement funding was considerably reduced with costs amounting to more than $250 million. The agency therefore decided to take advantage of new state legislation passed in the prior biennium allowing state agencies to use utility savings performance contracting as a means to replace aging and inefficient equipment. In such contracts, the utility savings will pay for the more efficient equipment cost over a fifteen-year period.

The utility savings are measured over the life of the contract in order to ensure the savings stream and maintain the savings guarantee. The agency chose an energy services firm specializing in performance contracting. This company uses a utility bill analysis software tool based on cooling degree-days and heating degree-days [1]. To date, savings have accrued for over two years for the first phase of the project and are presented in this paper for one of the measured electric meters. This paper focuses on the on-going savings stream to demonstrate the importance of continued measurement and verification on a representative meter at the Austin State Hospital located in Austin, Texas. In this paper, the Energy Services Company (ESCO) savings results are compared to savings results calculated from a regression analysis software [2] package using average outdoor air temperature data and actual pre- and post-retrofit data. The software 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 necessary to apply detailed as well as practical measurement and verification techniques. The agency continues to work 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

During the 2001 session, the 77th Texas Legislature passed a statute, which was then signed into law by the Texas Governor, directing State Agencies to explore all cost effective energy and water efficiency measures that were possible to finance with a fifteen year period. The Texas Health and Human Services Commission (HHSC), formerly the Texas Department of Mental Health and Mental Retardation (TDMHMR), signed an energy savings performance contract (ESPC) with a company specializing in equipment upgrades to comply with the legislation and meet immediate repair and replacement needs. The program began in November of 2002 when the agency issued a Letter of Interest to solicit responses from prospective 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 one 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 initially performed a preliminary utility audit survey of 23 campuses made up 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 separated the sites by region into five phases to perform 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 project has since been expanded by $20 million in order to perform additional work at another facility that was added to the agency. The funding will also add work at two facilities that previously received retrofits. 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 accomplish approximately $8 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 the 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 Texas state 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, high efficiency chillers, energy management and control systems, window films, low-flow faucets and showerheads, and low-flow toilets. Since most of the agency's campuses did have a control system in-place, addition to this project scope 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 in the existing 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 water heating systems.

The ESPC project was originally divided into five phases that embody typical ESPC opportunities such as those described for Phase One. Phase One with five campuses had a cost of $13.9 million and will provide the agency with approximately $1.47 million in annual savings now that it is fully implemented. Phase Two, now complete, included work at five additional sites at a total cost of $11.5 million and will generate $1.24 million in annual savings. Phase Three, also complete, includes another five sites and will save approximately $1.4 million annually at a cost of $13.1 million. Phases Four and Five are currently in the implementation stage. An additional 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.

As part of the additional $20 million in loan funding the agency received to expand the work

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currently being accomplished in Phases Four and Five, Phase Seven was added. This phase includes a new facility recently incorporated into the agency as well as additional work to two Phase One sites adjacent to the new one that did not receive certain retrofits. Originally, the work was not accomplished due to lower utility rates at the time and a complex utility interconnection between two of them. Now that the additional site is included in the agency, the interconnection is no longer an issue. Table 1 summarizes the project including phase number, number of sites in each phase, implementation cost, and expected calculated savings.

	# of Sites	Cost ($M)	Savings ($M/yr)
Phase I	5	$13.9	$1.5
Phase II	5	$11.5	$1.2
Phase III	5	$13.1	$1.4
Phase IV	3	$11.4	$1.2
Phase V	3	$12.1	$1.3
Phase VI	4	$5.2	$0.6
Phase VII	3	$7.4	$0.8

Table 1. Project Summary

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

An important portion of a performance contract involves a good M&V methodology to determine savings. It is in the best interest of the agency and the ESCO to have a good working relationship to make the project as successful as possible. The agency must have a guarantee 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 and 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 in the early stages of the audit. 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 often make this decision thinking it will save annual M&V fees because they wrongly 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 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. In most cases, savings will fall off because old operator habits generally tend to return causing energy consumption to increase by 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% without effective M&V. If no M&V analysis exists to reduce "savings loss creep", 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.

The annual M&V cost for Phase One 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 is in the best interest of the company

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 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 mostly 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 software that used 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.

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. Both parties recognized that personnel on each side 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.

M&V MODELS
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

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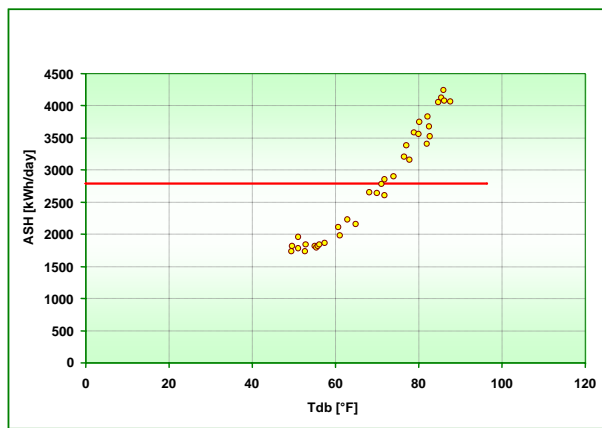
Mean: E = 2790.9698 kWh/day as shown in Figure 1.

Figure 1. Simple Mean Value

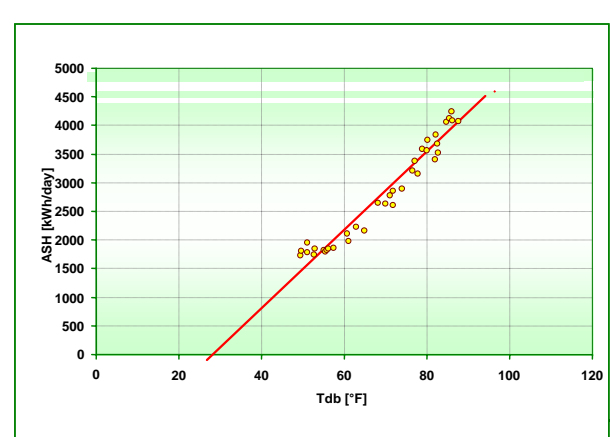2P: E = (66.6639*(OAT) – 1826.4315) kWh/day as shown in Figure 2.

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.

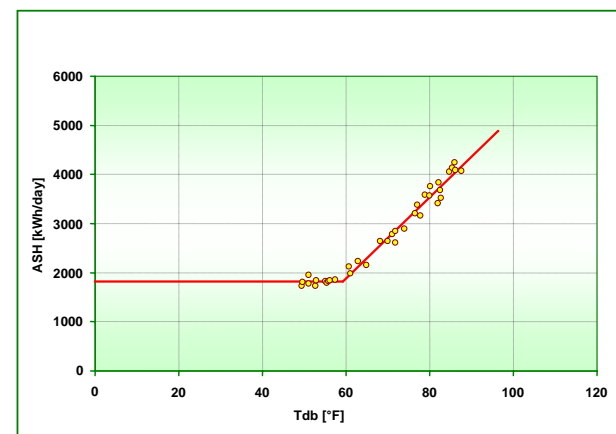Figure 3. 3P Model (Showing Change Point)

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
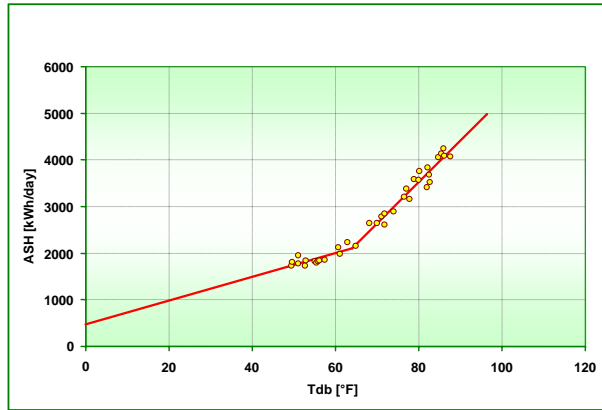as shown in Figure 4.

Figure 4.   4P Model (Showing Change Point)

The first calendar year of operation spanned January 4, 2005 through January 3, 2006. 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 January 2005 through December 2006 for two years. 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 2 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 one of these more sophisticated approaches were used. The second calendar year included January 4, 2006 to January 2, 2007 with the results shown in Table 3. The data also showed excellent agreement between the ESCO calculations to the 3P and 4P models using IMT.

	Vendor Calculation	Agency Calculations				
	Savings	1P	2P	3P	4P	
Jan	12,212	37,940	7,049	10,646	10,628	kWh/Mth
Feb	14,100	40,366	14,390	12,097	14,394	kWh/Mth
Mar	14,426	39,055	21,577	12,710	15,250	kWh/Mth
Apr	14,174	27,109	23,530	18,054	15,748	kWh/Mth
May	20,989	12,149	24,421	22,960	22,045	kWh/Mth
Jun	29,016	-3,633	25,605	28,284	28,789	kWh/Mth
Jul	29,174	-9,135	24,534	27,997	28,744	kWh/Mth
Aug	28,248	-9,500	23,371	26,936	27,746	kWh/Mth
Sep	35,142	-1,296	31,040	34,177	34,813	kWh/Mth
Oct	17,868	23,997	24,105	19,973	18,169	kWh/Mth
Nov	19,110	33,635	23,523	16,453	13,600	kWh/Mth
Dec	15,634	47,280	12,534	15,112	15,730	kWh/Mth
Total	250,093	237,968	255,679	245,400	245,658	kWh/yr
% Deviation		4.8%	-2.2%	1.9%	1.8%	

Table 2. Yr 1 Electrical Savings Comparison

	Vendor Calculation	Agency Calculations				
	Savings	1P	2P	3P	4P	
Jan	9,764	36,849	15,824	9,555	13,333	kWh/Mth
Feb	14,327	41,108	13,832	12,839	14,636	kWh/Mth
Mar	25,640	37,359	32,112	25,932	23,356	kWh/Mth
Apr	25,105	18,487	28,976	27,230	26,230	kWh/Mth
May	24,739	10,660	26,665	26,115	25,513	kWh/Mth
Jun	38,615	7,136	35,939	38,214	38,554	kWh/Mth
Jul	42,503	1,855	36,793	40,862	41,845	kWh/Mth
Aug	36,932	-7,154	30,034	34,802	36,038	kWh/Mth
Sep	29,095	5,287	28,956	29,980	29,890	kWh/Mth
Oct	12,608	15,462	18,403	14,963	13,396	kWh/Mth
Nov	12,127	30,231	19,553	12,344	9,443	kWh/Mth
Dec	11,519	41,434	8,421	9,266	10,551	kWh/Mth
Total	282,974	238,715	295,509	282,101	282,785	kWh/yr
% Deviation		15.6%	-4.4%	0.3%	0.1%	

Table 3. Yr 2 Electrical Savings Comparison

CURRENT STATUS

Construction of the first phase is complete with over two complete years of savings now available. Determining savings based on measurement has a high priority with the agency since the first two 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 and insure that real savings are maintained. Since the ESCO has responsibility for using measurements to calculate the savings over the life of the project, a separate analysis is randomly used to verify the ESCO's savings report.

The agency continues 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, monthly, quarterly, and according to project phase. Total savings are reconciled annually.

Figure 5 summarizes cumulative savings for the most recent data available showing the savings of each utility component for Phase One sites. The annual guarantee is also included 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.

SUMMARY

This paper demonstrated the continued savings of a performance contract by using savings models from the ESCO's software and comparing them 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 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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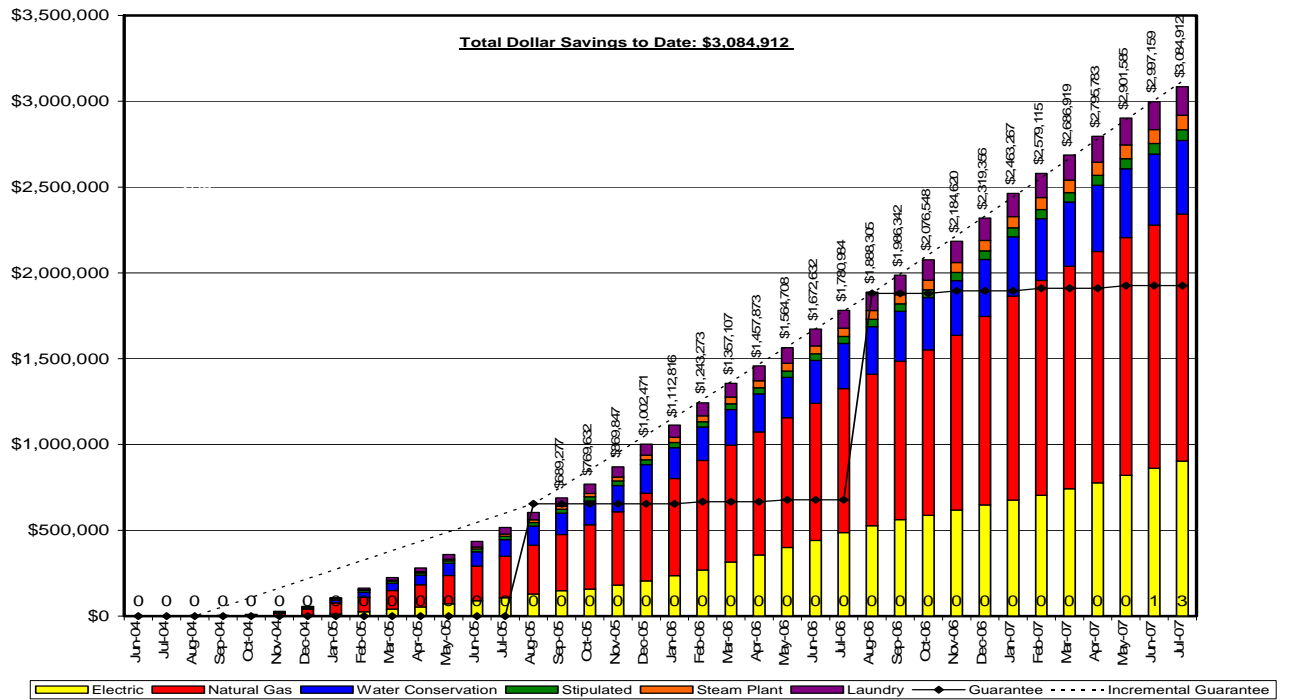[6] US Air Force (2005), "Facility Energy Management Program", http://www.afcesa.af.mil/ces/cesm/energy/cesm_ energy.asp.

Figure 5. Cumulative Savings versus Guarantee