LOANSTAR AFTER 11 YEARS: A REPORT ON THE SUCCESSES AND LESSONS LEARNED FROM THE LOANSTAR PROGRAM

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ABSTRACT

The Texas LoanSTAR program, which began in 1988, has produced over $110 million savings from energy conservation projects applied to state and local government buildings. One of the key features of LoanSTAR has been the monitoring and verification of the savings. Nationally, LoanSTAR has served as a showcase for other states to follow. LoanSTAR M&V methods have become the foundation for the the USDOE's NEMVP, IPMVP and ASHRAE's Guideline 14P.

However, underneath the success of the LoanSTAR program are many lessons that have been learned that are not as highly publicized. This paper will present an overview of 11 years of measured savings from the LoanSTAR program, including the cost effectiveness of the LoanSTAR loans, trends in LoanSTAR funding, lessons learned about how to reduce the cost of a revolving loan program while maintaining quality control, and a discussion of the LoanSTAR emissions reductions.

INTRODUCTION

The Texas LoanSTAR (Loans to Save Taxes And Resources) Program was established in 1988 by the Texas Governor's Energy Office (GEO) as a revolving loan program for funding energy conserving retrofits in state and local government buildings. The program has been very successful. One of the important features of the LoanSTAR program is the Monitoring and Analysis Program developed by the Energy Systems Laboratory that measures and reports energy savings from the retrofits using hourly before-after measurements in sites where the cost of the retrofit exceeds $100,000. At such sites data acquisition systems are ideally installed six to twelve months prior to the retrofit to monitor energy consumption so that an hourly whole-building, before-after analysis can be used as the basis for calculating savings. Numerous papers have documented the successes and procedures developed in the LoanSTAR program, including Athar et al. (1998), Claridge et al. (1991, 1992, 1994, 1996), Kumar et al. (2002), Turner et al. (1992, 2000), and Verdict et al. (1990).

CUMULATED MEASURED SAVINGS

As of April 2002 the LoanSTAR program is measuring savings for 32 loan sites covering 298 buildings where retrofits have been fully or partially completed. The completed retrofits show $78 million[1] in measured[2] savings, which are broken down into three components as shown in Figure 1: electricity savings of $4.6 million (41%), cooling savings of $2.8 million (42%), and heating savings of 1.6 million (37%). When combined with $27.6 million in Continuous Commissioning[SM] savings[3], $10.4 million in estimated savings from 98 sites using annual comparisons, for a total program savings of $112.7 million[4] as shown in Figure 2. It

[1] The $78 million in metered savings include $3.3 million in savings which are also included in the Continuous Commissioning[SM] savings shown in Figure 1.
[2] The phase "measured savings" is used here to denote where measurements are made during the baseline period, and during the post-retrofit period. A regression model of the baseline period is then developed and the parameters from the model are used to project the baseline energy use into the post-retrofit period. Measured savings are then calculated by comparing the post-retrofit energy use with the projected baseline energy use.
[3] The term "Continuous Commissioning[SM] or CC[SM]" refers to the technology developed by the Energy Systems Laboratory whereby the Laboratory, working closely with the building operators, uses continuous energy use monitoring, to optimized the HVAC system's operation, reduce and then maintain its reduced energy use. The Laboratory is currently working closely with the Texas State Enegy Conservation Office to help transfer this technology to the HVAC industry in Texas through a series of workshops. The Laboratory also works directly with Texas State Agencies to apply Continuous Commissioning[SM] to individual facilities.
[4] Savings include $3.2 million in savings overlap between retrofit savings and Continuous Commissioning[SM] savings.

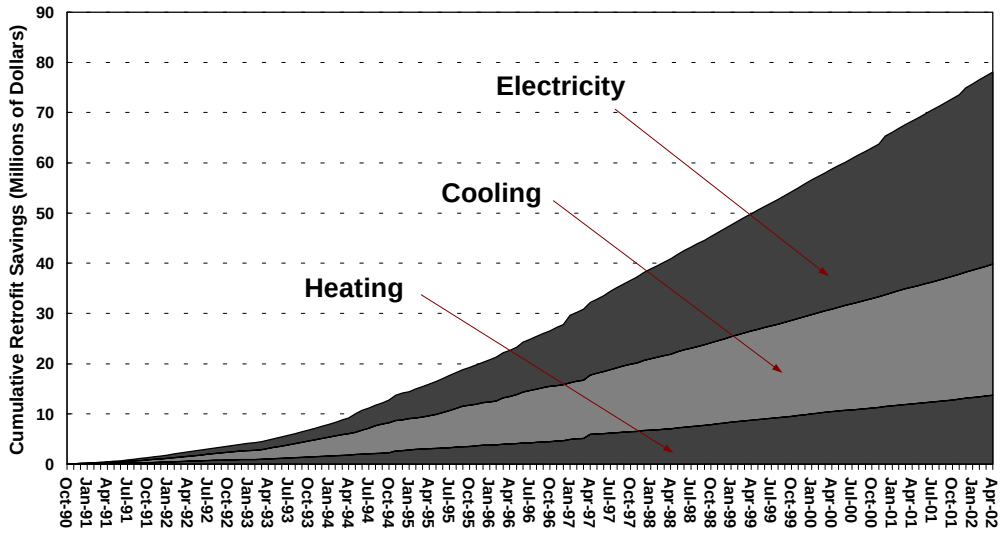

Figure 1. *Cumulative Metered LoanSTAR Retrofit Savings for the Period 1990 – 2002: $78,069,000 (includes CC savings overlap of $3,317,000 as of April 2002).*

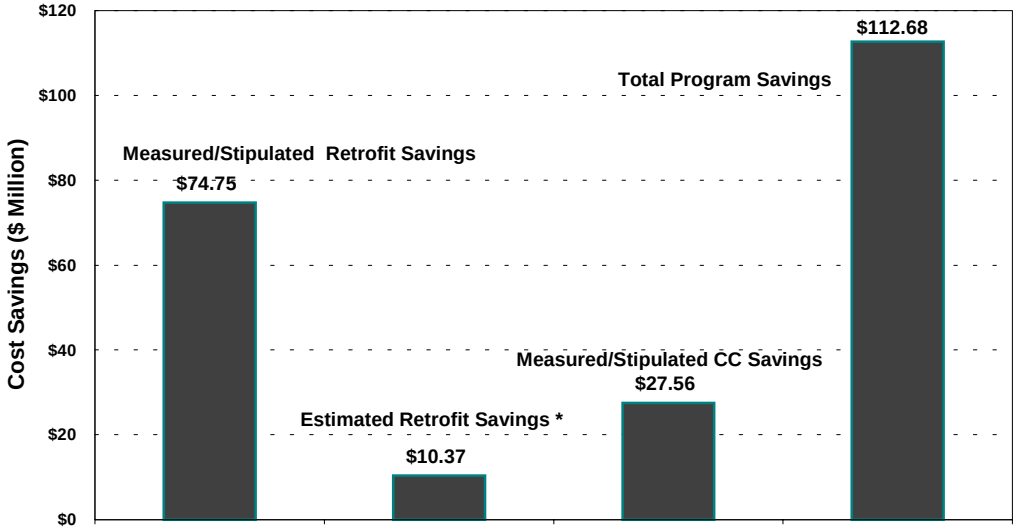

Figure 2. *Cumulative Total LoanSTAR Savings for the Period of 1990 – 2002: $112,678,000.*

is interesting to note that these savings are 117% of the audit-estimated savings, which were estimated by the engineering consultants who designed the retrofits under contract to the Texas State Energy Conservation Office (SECO).

The success of LoanSTAR's measured savings has been recognized by the USDOE and USEPAas a model program for its effectiveness and ground-breaking work. The data analysis methods developed in the program have also been adopted as the basis for the before-after (Option C) and the calibrated simulation procedures (Option D) in the North

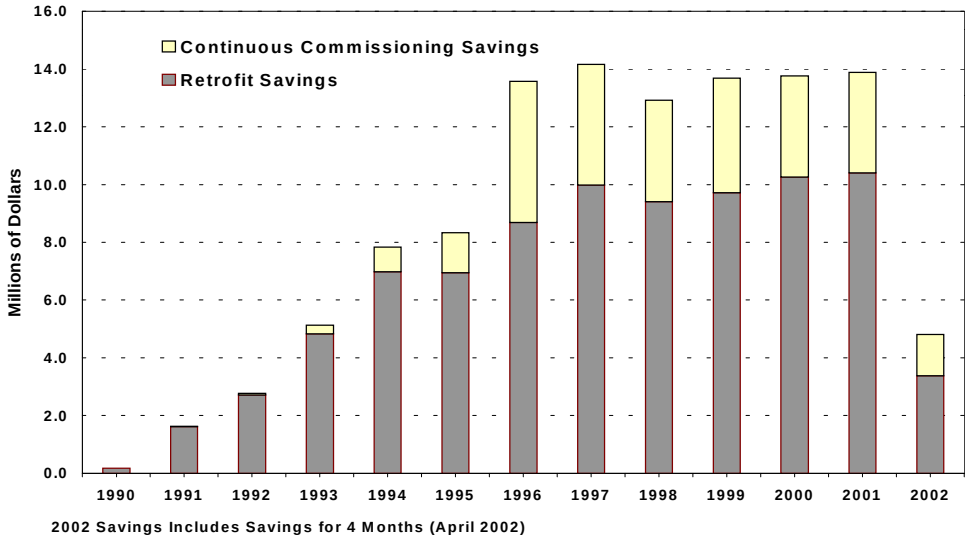

Figure 3. *Annual Savings from the LoanSTAR Program Including Continuous Commissioning[SM] for the Period 1990 – 2002.*

American Energy Measurement and Verification Protocols (NEMVP 1996), and the 1997 and 2000 International Performance Measurement and Verification Protocols (IPMVP 1997, 2001). LoanSTAR before-after analysis methods calibrated simulation methods are referenced in Guideline 14P under development by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE Guideline 14P 2002).

LESSONS LEARNED FROM THE LOANSTAR PROGRAM

Although the LoanSTAR program has been successful in its measurement of energy savings much can learned from the LoanSTAR program as is evident when one takes a closer look at the details. For example, in Figure 3 the yearly savings from the LoanSTAR program are shown, including $27.6 in Continuous Commissioning[SM] savings which began in 1993 and grew until 1997, when the effort was discontinued[5]. In the shaded portion of each year's value it is clear that the annual savings increased at a steady rate from 1990 to 1996, and then leveled-off in 1997 at about $10 million. Whereas, the total program savings increased by over $2 million in 1996, which is due in part to the Continuous Commissioning[SM] effort. Unfortunately, this rapid rise in savings was soon halted by programmatic decisions. First, the Continuous Commissioning[SM] effort was discontinued in 1997. Second, the payback period for the LoanSTAR program as extended from 4 years to 8 years in 1998 to allow more projects to qualify that could not meet the 4 year payback criteria. The impact of these two decisions can be clearly seen in Figure 4.

Figure 4 shows the total annual LoanSTAR retrofit expenditures and savings for the period 1991 to 2000 (Kumar et al. 2002). In 1991, the first year of recorded savings, the program had loaned $17,770,965. LoanSTAR reached a peak of $55,635,428 in loans 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.

In the LoanSTAR program the metering costs are fixed at 3% of the retrofit costs, and about 1 – 2% per year for reporting an analysis. A review of the Annual Energy Consumption Reports (AECR) submitted to SECO reveal that several "trends" are observable when we compare the estimated vs. actual

[5] During the period from 1993 to 1997 Continuous Commissioning[SM] was funded as part of the LoanSTAR program. Since 1997 Continuous Commissioning[SM] procedures have also been applied to the Texas A&M University campus, resulting in a savings of more than $3 million per year. LoanSTAR funding has also paid for Continuous Commissioning[SM] at Texas Tech University, which has resulted in $250,000 in savings for the period 2000 - 2002.

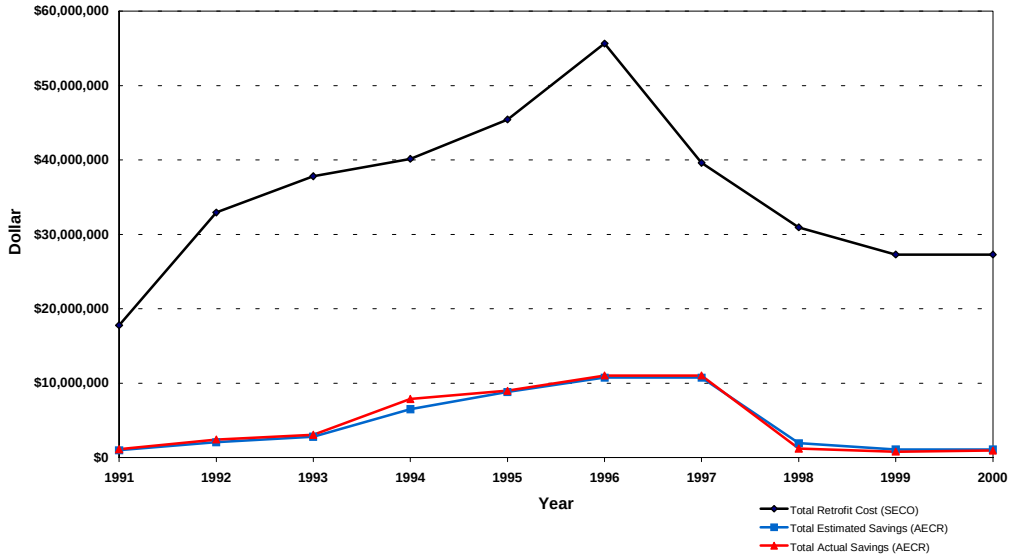

Figure 4. *Total annual LoanSTAR retrofit expenditures and savings: 1991 – 2000.*

energy savings. First, is the fact that the estimated energy savings can over or under-predict the actual savings from 30% to almost 220% emphasizing the need for verification of energy savings, as shown in Figure 5.

Second, in Figure 5, which shows the multiyear realization rates for individual LoanSTAR buildings from 1991 to 2000, the realization rate is defined as the actual savings divided by estimated savings. 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. This gradual decline in the realization rate also corresponds to drop in the program return and annual LoanSTAR loan rate.

Finally, in Figure 6, 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.

These findings are consistent with other analysis that confirms the need for continuous monitoring of savings from energy conservation retrofits. Specifically, these analysis show that the sites with utility bill tracking only showed 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).

LOANSTAR EMISSIONS SAVINGS

Another benefit of the measured LoanSTAR savings has been the ability to calculate potential emissions savings from the energy conservation (Athar et al. 1998). As of April 2002, the total potential emissions reductions for the measured retrofit savings for the period 1990 to 2002 amounted to 4,110 tons NOx, 1.2 million tons CO_2, and 2,667 tons SO_2, as shown in Figure 7. Since the energy savings were primarily derived from hourly measurements, potential emissions savings can be

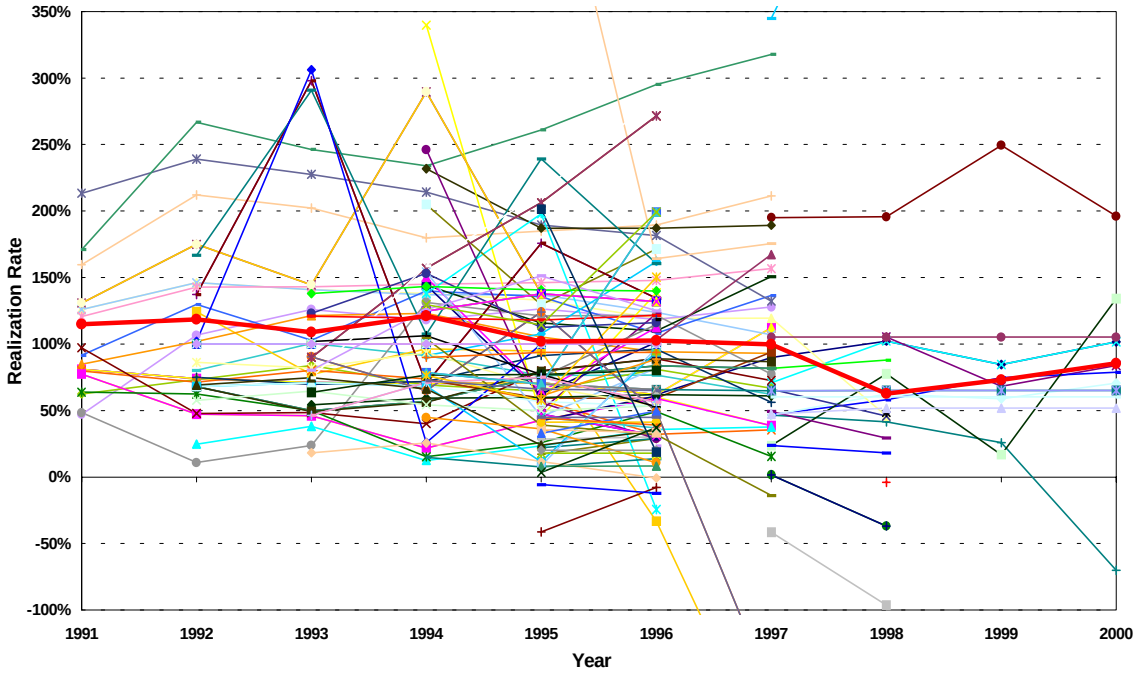

Figure 5. *Multi-year realization rate for LoanSTAR buildings (building data: 1991-2000).*

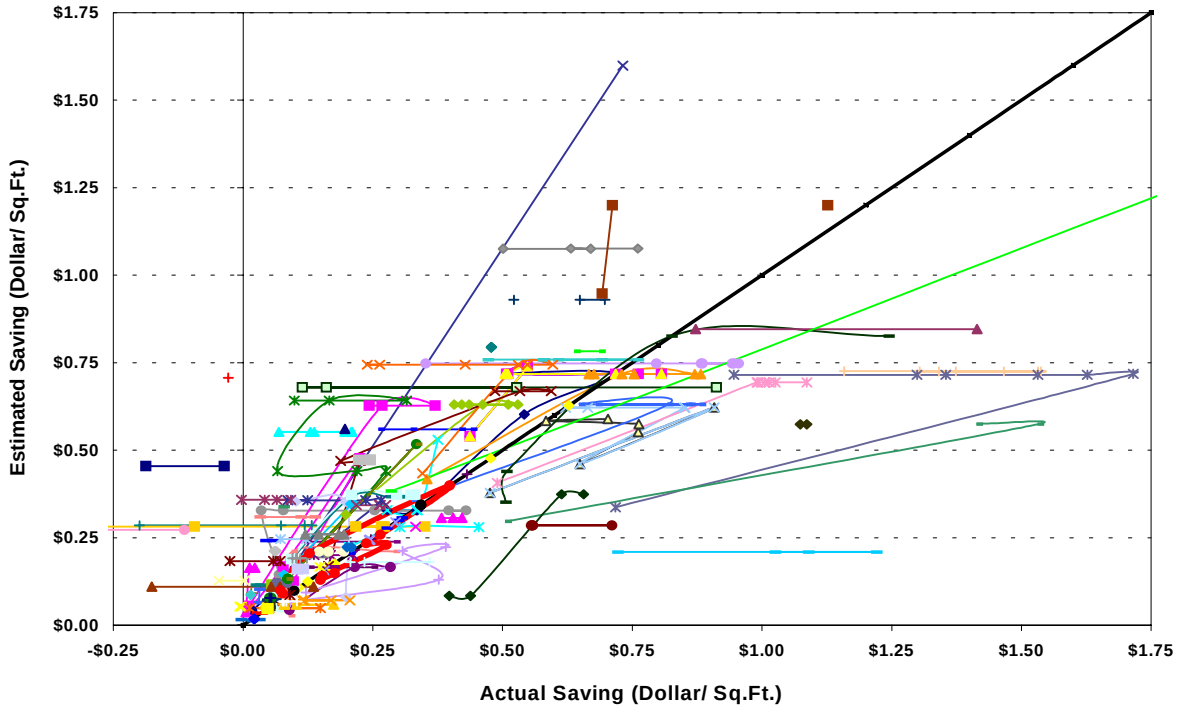

Figure 6. *Multi-year realization rate for LoanSTAR buildings (profiles: 1991 – 2000)*

broken-down into heating (1,087 tons), cooling electric (649 tons), and other electric (2,374 tons) savings. State average emission factors of Texas from the Environmental Protection Agency's report (EPA 1992)[6] are used to translate savings in natural gas to environmental emissions reductions. Chilled water savings in MMBtu are converted into equivalent electricity savings in MWh, it is further translated into reduced emissions with other electricity savings by using emission factors from the EPA-Green Light Report 6202J[7] (EPA 1992). The emissions reduction from the above three categories can help to indicate which energy conserving features are most likely to contribute to NOx reductions.

For example, although both heating and cooling have similar thermal energy reductions (i.e., 3.1 vs. 2.8 million MMBtu, respectively), it is interesting to note that energy conservation retrofits involving heating has significantly more NOx reductions than cooling. However, the majority of the heating NOx reductions occur in the winter when ozone formation from NOx does not rise above Environmental Protection Agency (EPA) limits. Therefore, calculating tons of NOx per day by dividing annual total NOx reductions (i.e., heating, cooling and electricity) would over-emphasize heating reductions and under-emphasize cooling reductions[8].

IMPACT OF CHANGING EMISSION FACTORS

There are a number of factors that influence the amount of emissions of a certain environmental pollutant as a result of burning a particular type of fuel. Not only do different types of fuels emit varying amounts of pollutants during the combustion process but the manner in which the fuel is burnt and the source of the fuel are also major factors in determining the amount of environmental emissions (Athar et al. 1998). Prior to 1990s, very little difference was observed for the annual emission factors published by EPA for Texas. However, in the 1990s the power plant emissions factors began to change dramatically as utilities and industries were mandated by the Texas Legislature to lower their NOx emissions, in an effort to reduce excessive ozone levels in the Houston-Galveston and Dallas-Ft.Worth areas. In Figure 8 the effect of the changing emissions factors is shown for the annual 2001 LoanSTAR emissions. In this figure the EPA's average, statewide emissions factors for 1992 are compared against the latest 2000 emissions factors. According to the EPA the utilities in Texas have successfully reduced their average, statewide NOx emissions to 61% of the early 1990 levels. At the same time SO_2 levels have been reduced to 80% of the previous levels. CO_2 have been reduced to 90% of previous levels. As these emissions levels continue to drop it is important to associate each year's energy savings with the appropriate emissions factors for the utility that supplied the electricity.

CONCLUSIONS

Currently, Texas has documented over $112 million in energy savings in hundreds of public buildings around the State of Texas. These energy savings have reduced the operating costs of these facilities and lowered the burden for taxpayers. LoanSTAR energy savings have also contributed substantially to a reduction in ozone-producing NOx emissions. Unfortunately, Measurement and Verification (M&V) on most of these buildings has been discontinued when the loans were paid back[9], which leaves an increasing likelihood that the actual cumulative savings may be less than the reported savings. Several studies by the Laboratory have shown that 20 to 30%+ of the savings will erode over time if these buildings are not carefully monitored[10], which would amount to a potential $2 to $3 million annual savings shortfall. Therefore, it is estimated that restarting the monitoring in these buildings and recommissioning the HVAC systems will likely produce substantial savings per year to the state, which will also have verifiable emissions reductions.

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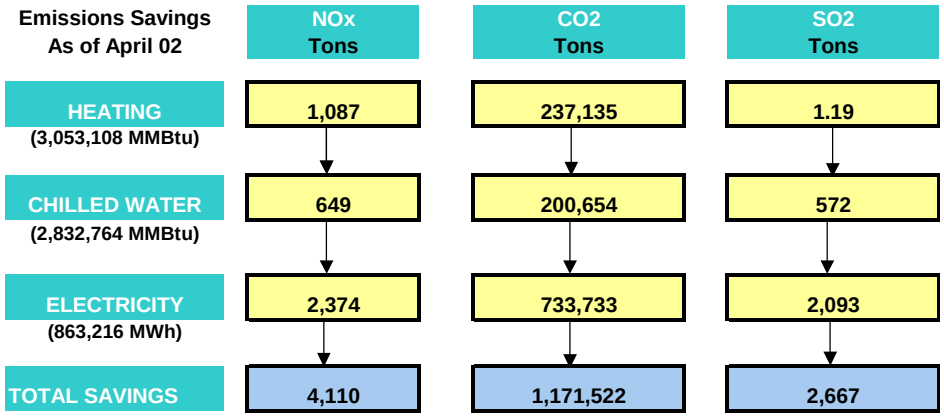
[6] State average (TX) emission factors reported by EPA in 1992 are: NOx: 0.53lbs/MMBtu, SO2: 0.00058 lbs/MMBtu, CO2: 117lbs/MMBtu

[7] National average emission factors reported in the 1992 EPA Green Light Report are: NOx: 5.50 lbs/MWh, SO2: 4.85 lbs/MWh, CO2: 1700 lbs/MWh

[8] NOx emission reductions which are attributable to cooling-related savings occur primarily in the summer when ozone is problematic for several areas of Texas. Procedures for accurately calculating ozone reductions require hourly electricity savings data, as well as an hourly electric grid distribution model, hourly weather data, and the appropriate power generation dispatch models.

[9] When the M&V is discontinued for a given site, the weather-adjusted savings for the last year are stipulated in future years.

[10] Additional information about this can be found in the papers: Kumar, S., Haberl, J., Claridge, D., Turner, D., O'Neal, D., Sharp, T., Sifuentes, T., Lopez, F., Taylor, D., "Measurement and Verification Reality Check: A Yawning Gap Between Theory and Practice", Proceedings of the 2002 ACEEE Summery Study, (August); and Claridge, D., Liu, M., Deng, S., Turner, D., Haberl, J., Abbas, M., Bruner, H., Veteto, B., Lee, S. 2001. "Cutting Energy and Cooling Use Almost in Half Without Capital Expenditure in a Previously Retrofit Building", Proceedings of the Summer Study of the European Council for an Energy Efficient Economy (ECEEE), June 11-16, 2001, Mandeliu, Cote D'Azur, France.



The combined reduction in pollutants in tons resulting from heating, cooling, and electricity savings
The numbers in parantheses are the total heating, cooling , and electricity savings from the LoanSTAR sites

Figure 7. *LoanSTAR's potential for emissions savings: 1990 – 2002.*

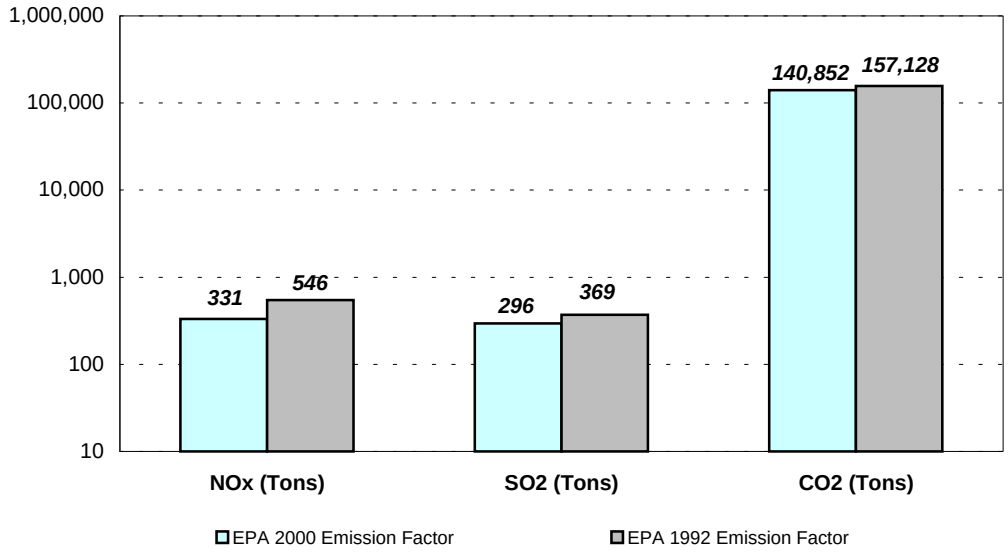


Figure 8. *Fluctuation 2001 LoanSTAR emissions rate*

the use of the LoanSTAR database for purposes of analyzing the cumulative program savings.

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