

## LOANSTAR ENERGY CONSERVATION AUDITS: JANUARY 1989 - AUGUST 1990

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### ABSTRACT

Fourteen audit reports, covering seventy buildings and Texas' Governor's mansion, have been accepted as a part of the Texas LoanSTAR Program. Task 1 (the first of five) is responsible for audit reviews and assignments. One hundred forty-five energy cost reduction measures (ECRMs) and maintenance and operation recommendations (M&Os) have been identified which can result in significant amounts of electrical energy, demand and natural gas savings. Costs savings are \$1,882,000/yr and the investment cost is \$5,566,000 for an overall simple payback of 3.0 years. The ECRMs and M&Os have been categorized as well as the types of buildings involved. The cost for auditing the 5.2 million square feet was \$0.054 per square foot. Problems associated with audit reports are also discussed.

### INTRODUCTION

In 1988, the Department of Energy approved a proposal which established the Texas LoanSTAR (Loan to Save Taxes and Resources) Program. The program is funded with \$98.6 million of oil overcharge funds. The majority of this money will be used to loan to state agencies, institutions and public schools to fund identified

administer the program and has divided the LoanSTAR Program into five tasks. This paper discusses the problems and results associated with the first task, which covers audit reviews and assignments.

### TASK 1 RESPONSIBILITIES

Energy saving retrofits are identified through energy audits performed by nine engineering consulting firms (with a total of approximately 15 audit teams) hired by the GEMC. An annual audit format training workshop is conducted by Energy Systems Laboratory personnel to train the auditors about audit guidelines and report format.

The Energy Systems Laboratory has employed a professional engineer to work at the GEMC and coordinate audit assignments. This professional engineer assigns an engineering firm (according to their workload, expertise and the location of the project) to each facility needing an audit. The assigned engineering firm performs a walk-through audit of the facility and generates a preliminary on-site screening report (POSSR). This POSSR identifies potential energy cost reduction measures (ECRMs) and

maintenance and operation recommendations (M&Os) that require more engineering analysis, as well as identifying facilities that don't require detailed auditing. It also includes the engineering firm's proposal to provide the detailed engineering analysis and report. Each firm is under contract with the GEMC to perform engineering services at identical hourly rates. The hourly rates are \$65.00/hr for project manager, \$57.50/hr for senior engineer, \$45.00/hr for staff engineer, \$27.50/hr for technician, and \$20.00/hr for clerical. The engineering firm also provides a start date and an anticipated completion date of the first draft report to be reviewed by Texas A&M University.

Next, the POSSR is reviewed by engineers at the GEMC and the Energy Systems Laboratory. Both audit costs and project feasibility are discussed at this time. Then, the engineering firm visits the state agency or institution for a more detailed analysis of projects identified by the POSSR. An average of five weeks elapses between assignments and receipt of the screening report (POSSR) and seven weeks between the POSSR and receipt of the first draft.

Upon receipt of the first draft of the audit report and all subsequent drafts, Energy Systems Laboratory

accurate reports with a high level of technical accuracy. Review of the first draft averages less than four weeks at Texas A&M. About three weeks (included in the review time) are allowed for the facility manager to comment on the first draft. Subsequent drafts are not submitted to the agency for comments unless there are substantial changes to the project. Engineering consulting firms spend an average of almost five weeks revising unsuitable drafts and Energy Systems Laboratory personnel spend an average of two weeks reviewing drafts beyond the first. The number of drafts required averages 2.6.

### TYPES OF BUILDINGS

From January 1989 to August 1990, the audits of seventy-one buildings, two streetlighting systems, and one steam distribution system were completed. This group of audits took place at three university campuses, a college of medicine, a MHMR state school, two cities, a military camp, and numerous state capitol buildings. The type of buildings audited include cafeterias, dormitories, athletic facilities, offices and classroom buildings, parking garages, physical plants and a residence and museum (the

Governor's mansion.) The area breakdown of the facilities by type of building is shown in Table 1.

The buildings can be grouped into three categories: simple, typical and complex. "Simple" includes gyms, indoor swimming pools, parking garages, work shops and warehouse space. "Typical" includes offices, classrooms, dorms, theatres, an infirmary, a chapel, a laboratory, and a residence and museum. "Complex" includes only physical plants and a steam distribution and return system. Hospitals, which lack representation in this phase of the program, will fall in the complex category.<sup>2</sup> A total of 868,000 square feet of simple space, 4,297,000 square feet of typical space, and 57,000 square feet of complex space were audited. Also audited were a steam distribution system and two city streetlighting systems, which have no associated areas. Not all buildings will be used in the cost evaluation by type because many of the audit reports were written as a single composite of up to twenty seven buildings of different types.

### ENERGY AND COST SAVINGS IDENTIFIED

Thirteen energy audit reports (including twelve facilities with 70 buildings and two city-wide streetlighting conversion reports)\* have been completed and accepted by Texas A&M. Once the report is accepted, the facility is eligible for a LoanSTAR loan equal to the implementation cost indicated in the report. The ECRMs and M&Os combined identify a total potential savings of 39,500,000 kwh/yr, 12,600 KW-mo/yr, and 220,000 MCF/yr of natural gas, worth \$1,882,000/yr at an estimated implementation cost of \$5,566,000, resulting in an overall simple payback of 3.0 years.\*\*

The LoanSTAR Program will fund loans to facilities on identified ECRMs only with an overall simple payback of 4.0 years or less. In addition, the amount necessary to pay for the audit and POSSR is included in the loan. The ECRMs from all thirteen reports have identified potential savings of 37,300,000 kwh/yr, 10,800 KW-mo/yr, and, 213,000 MCF/yr of natural gas worth \$1,767,000 at an estimated implementation cost of \$5,559,000, resulting in an overall simple payback of 3.5 years. The ECRMs and M&Os can be divided into the following eight categories:<sup>3</sup>

1. Lighting Projects
2. Heating, Ventilation, and Air Conditioning (HVAC)
3. Electrical Equipment/Distribution (including variable frequency drives)

\* Not including the Governor's mansion.

\*\* The energy savings mentioned do not include 9,548 MMBtu/yr of ton-hr and steam savings for four ECRMs and 514 MMBtu/yr of ton-hr and steam savings for four M&Os; however, the cost savings and implementation costs from the projects are included. Furthermore, the simple payback does not include the cost of the audit.

4. Building Shell Improvements
5. Energy Management Systems
6. Boiler Efficiency Improvements
7. Energy Recovery Systems
8. Miscellaneous

A total of 145 projects (126 ECRMs and 19 M&Os) are identified in the thirteen reports. Tables 2 and 3 show the greatest cost saving projects for each category for all projects saving more than \$10,000/yr. A steam trap survey, lighting conversion of 400-watt mercury vapor to 200-watt high pressure sodium, and double duct to VAV conversion are the ECRMs with greatest cost savings. These account for over \$537,000 worth of potential annual energy savings. Table 4 shows the projects with the shortest simple payback for the ECRMs, and also shows the averages for each category. All ECRMs combined have an average annual savings of 295,000 kwh, 86 KW-mo, and 1700 MCF of natural gas worth \$14,023 annually with an implementation cost of \$44,120. All of the 19 M&Os had paybacks of 2.0 years or less.

### AUDIT COST

The overall audit cost (including the POSSR) was \$0.054 per square foot. The preliminary surveys cost an average of \$0.003 per square foot, while the detailed audit averaged \$0.051 per square foot. The 1986 costs of audits under the Texas Energy Cost Containment Program averaged \$0.050 per square foot, and the surveys averaged \$0.003 per square foot. The 1986 program audited in detail 13.5 million square feet, of which 37 percent was complex.<sup>2</sup> The LoanSTAR program has completed 5.2 million square feet of audits to date, of which only about one percent is complex. In comparison, the overall cost of audits has changed very little (less than two percent).

The audit costs by category are broken down as follows: The simple spaces cost \$0.023 per square foot. The typical spaces averaged \$0.048 per square foot. Physical plants (a complex space) varied widely in audit costs from \$0.192 to \$1.926 per square foot, averaging \$0.591 per square foot across four plants.

Two facilities which were done as composites, and about which very little individual building information was given, will not be included in the following analysis by category. This will remove thirty buildings from the database and only buildings (no streetlighting systems, etc.) will be included. POSSR costs will also not be included in any breakdown costs. For simple space, (made up of three parking garages, three gymnasiums/pools, and a workshop/warehouse) the total payback, including audit cost, averages 4.8 years. In the complex category, all four physical plants are included and the average payback is 4.6 years. The payback drops to 2.9 years in the typical category, using 30 samples. These are shown in Table 5. The audit costs increase the payback 0.7, 0.2, and 0.1 years for the simple, typical and complex spaces respectively. An evaluation of the audit costs, implementation costs and energy cost savings is also given in Table 5 on an area basis.

When utility cost is analyzed, the usable sample group diminishes greatly because few of the institutional and governmental buildings are individually metered. Therefore, much of the utility costs data for individual buildings are either rough estimates or do not exist. The typical category has eleven samples remaining that can be considered as having "known" utility costs. The simple and complex categories have too few samples remaining to be considered representative; these categories will not be discussed. Using only the small representative group of samples, the Energy Cost Index (ECI) for the typical category is \$1.89 per square foot. The ECI ranges from \$0.82 per square foot to \$2.39 per square foot in this group. The percent of project utility costs savings ranges from five percent to thirty percent, and averages sixteen percent.

### PROBLEMS IDENTIFIED IN TASK 1

As stated earlier, the average number of draft reports is 2.6. This value is well beyond the Energy Systems Laboratory's 1986 experience with the Texas Energy Cost Containment Program (TECCP) reports that commonly required only one or two reviewed drafts. This has required spending more review effort per report. The following is a partial list of problems identified with LoanSTAR drafts:

1. The reports do not reflect the current rate schedule or do not calculate the avoided costs of energy and of electrical demand properly.
2. The reports inadequately document the implementation costs.\*\*\*
3. Assumptions are used without proper identification.
4. Consulting firms are requiring repeated instructions on the same items in several drafts of the same report.
5. Corrections within an ECRM are not changed throughout the report (i. e., executive summary and composite ECRM).
6. Consulting firms are not sending the required number of copies of a draft report.
7. Running a building simulation program for a sample building in the program's menu rather than the actual building.

8. Pages and report sections not in appropriate order as required by the sample format provided in the guidelines. This also includes references to support data in the appendix which does not exist or cannot be extracted from a provided curve or table.
9. Final numbers are stated without providing a sample calculation including the appropriate units; or, the provided calculation doesn't have the units which has sometimes led to a conversion error.
10. The report fails to cover all the ECRM listed in the POSSR.
11. The report fails to include the last, composite ECRM; or, the composite ECRM just sums the individual ECRMs and does not take into account the interdependencies as required by the guidelines.
12. Erroneous statements are made about building equipment.
13. ECRMs have contradictory statements in the narrative describing the task.
14. Projected completion dates within the POSSR are consistently not being met.
15. Mathematical errors.
16. Tables with calculations are in error because the spreadsheet uses the numbers from a different ECRM.

In part due to the recurring errors above, Task 1 personnel have been asked by the GEMC to revise the guidelines to accomplish several aims: streamline the reporting process by requiring less ancillary descriptive material; provide a general descriptive section on maintenance and operation procedures in order to encourage facility personnel to identify additional M&Os; and, better define acceptable documentation for implementation costs. Also, a checklist of ECRMs has been generated for use at the screening stage in an attempt to assure that important projects are not overlooked. Furthermore, Task 1 is currently evaluating the possibility of further simplifying the guidelines and report format to eliminate problems and reduce audit costs.

\*\*\* It is interesting to note that a similar problem with the lack of implementation costs documentation occurred with the Institutional Conservation Program in Texas.<sup>4</sup>

## CONCLUSION

Task 1 of the Texas LoanSTAR Program is responsible for audit reviews and assignments. Professional engineers, located at the GEMC and Energy Systems Laboratory, administer the program. Buildings from university campuses, the state capitol complex, a military camp, state schools and other facilities were audited from January 1989 to August 1990. These buildings are categorized into three groups: simple, typical, and complex. In total, thirteen audit reports (126 ECRMs and 19 M&Os) identified potential savings of 39,500,000 kwh/yr, 12,600 KW-mo/yr, and 220,000 MCF/yr of natural gas, worth \$1,882,000/yr with an implementation cost of \$5,566,000, resulting in an overall simple payback of 3.0 years. The ECRMs and M&Os have also been categorized according to the type of retrofit project.

A total area of 5.2 million square feet consisting of approximately 868,000 square feet of "simple" space, 4,297,000 square feet of "typical" space, and 57,000 square feet of "complex" space were audited at an average cost of \$0.054 per square foot. Several problems have also been encountered during the audit process.

## REFERENCES

- 1 "Audit Guidelines and Training Manual", LoanSTAR Program, Governor's Energy Management Center, Austin, Texas, February 1990.
- 2 "Audit Costs for 1986 Texas Energy Cost Containment Program", W. M. Heffington, S. K. Lum, V. A. Bauer, and W. D. Turner, Fourth Annual Symposium on Improving Building Energy Efficiency in Hot and Humid Climates, Houston, Texas, September 15-16, 1987.
- 3 "Update Report on Texas Energy Costs Containment Program", W. M. Heffington and T. E. Burke, Mechanical Engineering Department, Texas A&M University, College Station, Texas, 1988.
- 4 "Building Energy Use and Conservation in Cycle VIII of the Texas Institutional Conservation Program," R. C. Schrecengost, S. K. Lum, J. R. Notman, D. R. Sattler, and W. M. Heffington, Third Annual Symposium on Improving Building Energy and Efficiency in Hot and Humid Climates, Austin, Texas, November 18-19, 1986.

TABLE 1  
BUILDING AREA BY TYPE

BUILDING TYPE	NO. OF BLDGS.	CATEGORY	TOTAL AREA (SQ. FT.)	SIZE RANGE	
				SMALLEST (SQ. FT.)	LARGEST (SQ. FT.)
CAFETERIA	4	TYP	20,268	2,720	10,610
DORMITORY	17	TYP	518,368	8,400	52,600
GYM/POOL	4	SIMP	172,252	11,283	72,669
INFIRMARY	1	TYP	12,763		
LABORATORY	1	TYP	125,000		
OFFICE	10	TYP	2,020,106	1,944	503,000
OFFICE/CLASS	11	TYP	925,373	45,465	261,000
CLASSROOM	10	TYP	343,100	2,592	253,200
THEATRE COMPLEX	2	TYP	202,471		
LIBRARY	1	TYP	110,000		
CHAPEL	1	TYP	4,221		
PARKING	3	SIMP	607,247	17,644	319,550
POWER PLANT	4	CMLPX	56,556	8,436	24,900
REPAIR SHOP/WAREHOUSE	1	SIMP	88,229		
RESIDENCE/MUSEUM	1	TYP	15,792		
STREETLIGHTING	2 SYS		N/A		
TOTALS	71		5,221,746		

TABLE 2  
ECRMs BY GREATEST COST SAVINGS

DESCRIPTION	CAT	ELECT. ENERGY SAVINGS (Kwh/yr)	DEMAND SAVINGS (KW-mo/yr)	NAT. GAS SAVINGS (MCF/yr)	COST SAVINGS (\$/yr)	IMPLEM. COST (\$)	PAY- BACK (yr)
STEAM TRAP SURVEY	6	0	0	97799	\$275,793	\$105,692	0.4
CONVT 400 MV - 200 HPS	1	7001400	0	0	\$162,148	\$483,430	3.0
DOUBLE DUCT VAV CONVERSION	3	2736591	0	2732	\$99,696	\$445,080	4.5
VARIABLE SPEED DR - AHU	3	2970770	111	2370	\$88,251	\$287,600	3.3
INTERCONNECT BLDG CW PIPING	2	-280582	2142.4	37373	\$79,892	\$203,862	2.6
UPGRADED EMS	5	2269946	0	0	\$78,994	\$260,170	3.3
VARIABLE SPEED DR - AHU	3	2323100	6	190	\$73,656	\$231,375	3.1
CONVT 400 MV - 200 HPS	1	2539320	0	0	\$62,437	\$175,334	2.8
INSTALL ELECTRIC SCREW CHILLER	2	27600	-2382	19520	\$61,852	\$397,530	6.4
ADD EE CHILLER - ADD BLD LOOP	2	-795182	-3093	37600	\$59,084	\$451,847	7.6
HVAC MODIFICATIONS	2	1881700	0	0	\$54,687	\$52,720	1.0
INSTALL 600 TON CHILLER	2	1089428	1925	0	\$48,336	\$239,514	5.0
INTERIOR LIGHTING CONTROLS	1	1050800	1700	-240	\$43,611	\$107,222	2.5
INTERIOR LIGHTING CONTROL	1	883000	1426	-200	\$42,292	\$118,790	2.8
REDUCE PUMPING REQUMT IN CW PL	2	1193762	580	0	\$35,942	\$170,625	4.7
INTERIOR LIGHTING CONTROL	1	695600	1123	-160	\$33,317	\$79,750	2.4
PUMPING AND PIPING MODIFICATIO	2	1041200	64	0	\$32,991	\$167,820	5.1
EMS	5	864399	83	323	\$32,180	\$69,400	2.2
CONVT 400 MV - 200 HPS	1	756000	0	0	\$32,089	\$262,800	8.2
REPLACE CONDENSING UNITS	2	458462	2397.6	0	\$31,379	\$146,961	4.7
LIGHTING-EE AND PHOTOCCELL	1	713444	1524.3	-736.4	\$30,660	\$104,375	3.4
CONVERT TO A DDC EMS	2	852032	0	0	\$24,027	\$73,294	3.1
EMS	5	584165	112	428	\$23,077	\$76,320	3.3
INSTALL TWO-SP CLING TWR F MOT	2	517500	922	0	\$22,778	\$41,475	1.8
CONVT 400 MV - 200 HPS	1	917280	0	0	\$22,416	\$63,336	2.8
ADJ FREQ DR - AHU	3	571694	0	-139	\$15,773	\$56,590	3.6
UTILIZE EXISTING HEAT RECLAIM	7	28109	214	2450	\$15,731	\$22,315	1.4
DD CONTROL EM SYSTEM	5	594354	0	0	\$15,440	\$113,569	7.4
REPLACE EX CHILLER W/EE	2	369013	437	0	\$13,713	\$54,852	4.0
CHILLED WATER RESET TEMP	2	423417	0	0	\$13,126	\$30,400	2.3
STEAM SHUTDOWN /NEW BOILERS	6	-154450	-304	6540	\$12,995	\$28,018	2.2
REPLACE INCAND TO EE	1	349800	416	-230	\$12,519	\$41,375	3.3
REPLACE INCAND W/ EE LAMPS	1	270800	330	0	\$12,226	\$22,910	1.9

TABLE 3  
M&Os BY GREATEST COST SAVINGS

DESCRIPTION	CAT	ELECT. ENERGY SAVINGS (Kwh/yr)	DEMAND SAVINGS (KW-mo/yr)	NAT. GAS SAVINGS (MCF/yr)	COST SAVINGS (\$/yr)	IMPLEM. COST (\$)	PAY- BACK (yr)
FIX LEAKING VALVES	2	240,700	996	5,070	\$34,161	\$2,860	0.08
FIX AHU's TIMECLOCKS	5	717,080	0	323	\$26,230	\$70	0.00
FIX AHU's TIMECLOCKS	5	496,032	0	428	\$18,953	\$120	0.01
TURN OFF COMP & LITES	3	325,050	0	0	\$11,312	\$0	0.00

TABLE 4  
ECRMs BY CATEGORY AND SHORTEST PAYBACK

DESCRIPTION	CAT	ELECT. ENERGY SAVINGS (Kwh/yr)	DEMAND SAVINGS (KW-mo/yr)	NAT. GAS SAVINGS (MCF/yr)	COST SAVINGS (\$/yr)	IMPLEM. COST (\$)	PAY- BACK (yr)
LIGHT SWITCHING MODIFICATION	1	76000	170	100	\$3,981	\$1,753	0.4
DELAMP ABOVE BOOKSHELF AREA	1	52005	118	0	\$2,547	\$1,134	0.4
INSTALL MOTION SENSORS - LIGHT	1	10853	0	0	\$306	\$282	0.9
INSTALL 7-DAY TIMECLOCKS	1	15319	0	0	\$533	\$696	1.3
INSTALL MOTION SENSORS	1	18240	0	0	\$514	\$734	1.4
INSTALL MOTION SENSORS	1	27222	0	0	\$768	\$1,247	1.6
CAT. 1 TOTALS (51 ECRMs)		17676855	8709	-1661	\$539,495	\$1,811,635	3.4
CAT. 1 AVERAGES (51 ECRMs)		346605	171	-33	\$10,578	\$35,522	
SHUTDOWN EXHAUST FANS	2	265408	0	0	\$8,228	\$845	0.1
CONDENSER WATER SYSTEM ADJUST	2	19612	181	0	\$2,395	\$576	0.2
TRIM PUMP IMPELLER	2	142600	156	0	\$5,304	\$1,575	0.3
OUTSIDE AIR CONTROL MODIF.	2	9564	0	41	\$373	\$315	0.8
OUTSIDE AIR CONTROL MODIFIC.	2	6340	0	27	\$247	\$213	0.9
HVAC MODIFICATIONS	2	1881700	0	0	\$54,687	\$52,720	1.0
CAT. 2 TOTALS (32 ECRMs)		7420462	3330	96273	\$507,125	\$2,084,406	4.1
CAT. 2 AVERAGES (32 ECRMs)		231889	104	3009	\$15,848	\$65,138	
SHUTDOWN DOM HOT WATER/OFF HRS	3	5105	0	179	\$1,132	\$2,546	2.2
ADJ FREQ DR - AHUs	3	60022	0	-17	\$1,649	\$4,230	2.6
ADJ FREQ DR - AHU	3	169458	0	-43	\$4,671	\$13,090	2.8
ADJ FREQ DR - CW PUMPS	3	76835	0	0	\$2,167	\$6,000	2.8
VARIABLE SPEED DR - AHU	3	2323100	6	190	\$73,656	\$231,375	3.1
CAT. 3 TOTALS (29 ECRMs)		10438255	307	5051	\$333,143	\$1,241,717	3.7
CAT. 3 AVERAGES (29 ECRMs)		359940	11	174	\$11,488	\$42,818	
INSTALL DROPPED CEILING (ONLY ECRM IN CATEGORY 4)	4	0	0	1680	\$4,737	\$25,454	5.4
INSTALL 7-DAY TIMECLOCKS	5	18634	0	0	\$648	\$240	0.4
INSTALL 7-DAY TIMECLOCKS	5	16054	0	0	\$559	\$240	0.4
NIGHTTIME SETBACK CTRL < GAS HT	5	0	0	2734	\$8,804	\$7,522	0.9
EMS	5	864399	83	323	\$32,180	\$69,400	2.2
CAT. 5 TOTALS (8 ECRMs)		4407852	254	4405	\$165,272	\$550,277	3.3
CAT. 5 AVERAGES (8 ECRMs)		550982	32	551	\$20,659	\$68,785	
STEAM TRAP SURVEY	6	0	0	97799	\$275,793	\$105,692	0.4
BOILER PRESS REDUCT & NEW PUMP	6	91400	161	450	\$5,561	\$7,475	1.3
CAT. 6 TOTALS (4 ECRMs)		-63050	-143	106599	\$304,195	\$189,700	1.6
CAT. 6 AVERAGES (4 ECRMs)		-15763	-36	26650	\$76,049	\$47,425	
UTILIZE EXISTING HEAT RECLAIM (ONLY ECRM IN CATEGORY 7)	7	28109	214	2450	\$15,731	\$22,315	1.4
OVERALL TOTALS (126 ECRMs)		37257304	10800	213086	\$1,766,864	\$5,558,917	3.5
OVERALL AVERAGES (126 ECRMs)		295693	86	1691	\$14,023	\$44,118	

TABLE 5  
EVALUATION OF COST PER AREA

CATEGORY	NO. OF SAMPLES	AUDIT COST (\$/SF)	IMPLEMENT. COST (\$/SF)	ENERGY COST SAVINGS (\$/SF)	TOTAL PAYBACK
SIMPLE	7	0.023	0.145	0.035	4.8
TYPICAL	30	0.047	0.697	0.259	2.9
COMPLEX	4	0.591	18.08	4.044	4.6