BUILDING ENERGY USE AND CONSERVATION IN CYCLE VIII OF THE TEXAS INSTITUTIONAL CONSERVATION PROGRAM

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ABSTRACT

Sixty-two technical assistance (energy audit) reports by twelve different consulting firms representing fifteen independent school districts, nine hospitals, and five colleges have been reviewed to assess energy use characteristics and recommended energy saving measures. Such measures include both maintenance and operation (M&O) measures (generally regarded as "low-cost, no- cost") and energy conservation (ECM) measures (generally more expensive and requiring outside skills). Implementation cost, annual savings of energy and costs, and paybacks were reported for all M&Os and ECMs. Measures were broken down by the consulting firms according to energy use characteristics and categories, and it was determined that average costs for electricity and gas, before implementation of M&Os and ECMs, were \$0.0596/KWH and \$4.85/MMBTU respectively. The total implementation cost and projected annual savings for the M&Os are \$73,000 and \$223,000 respectively, yielding a four-month payback. The

ration of technical assistance reports along with the general background and implementation of the Institutional Conservation Program in Texas, resulting from the National Energy Act of 1978, are discussed.

INTRODUCTION

The Institutional Conservation Program (ICP) has its roots in the National Energy Conservation Policy Act of 1978. The ICP generally provides fifty percent of the funding for energy conservation measures in public and private non-profit schools (including colleges and universities) and hospitals to lower the energy use and costs. The program is administered by the Department of Energy (DOE) at the federal level and by the Energy Efficiency Division of the Public Utility Commission (PUC) at the state level. Guidelines and other program information are found in references 1 and 2.

There are two types of grants available from the federal government which an institution may seek under the ICP. The first deals with the identification of energy-saving measures and the second with implementation. Both require that fifty percent of the funding (a significant financial commitment) come from the institution. The first type of grant is a Technical Assistance (TA) grant. With this grant, an institution employs a professional engineer to perform an energy audit of selected buildings and identify and document possible energy-saving measures. The energy audit report is known as a Technical Assistance report and the format is specified by the Public Utility Commission of Texas [1,2]. Most of the work involved in preparing TA reports for Cycle VIII was accomplished in 1985 and early 1986. The guidebook [1] provides for two types of energy-saving measures to be performed in the building containing the hospital or school. Maintenance and operation (M&O) measures are projects which are inexpensive and are normally performed by existing maintenance personnel. An Energy Conservation Measure (ECM) is one which requires a significant amount of funds and may involve outside labor. Frequently, replacement or modification of major equipment is called for by an ECM. ECMs identified in the report as having simple paybacks in the range of two to ten years are eligible for matching funds through the second type of grant known as an ECM grant.

conservation among the institutions which are involved with this program. In order to encourage this spirit and to promote the idea that the ICP is more than just a source of one-time matching funds for major energy management projects, two things are required. First, all M&Os identified in the TA report must be implemented. In fact, the calculation of savings due to ECMs is predicated upon the implementation of the M&Os. Secondly, each institution involved in this program is required to prepare a thorough energy management plan. Preparation of this plan should involve strong institutional employee participation. The institution is required to certify that all M&Os will be implemented and to submit the energy management plan to the PUC.

The TA reports contain useful data on energy savings and costs of implementation for both M&Os and ECMs. This data is analyzed in order to assess the cost and effectiveness of various types of measures in different categories of facilities. The program also is a good source of building energy use data which can be used to calculate the effect of energy conservation actions. The amount of purchased energy used in the buildings considered by this program is analyzed, and the energy used by the various energy-using systems in the building is estimated. Energy cost and utilization indices are

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determined, and the effect on these indices due to M&O and ECM implementation are presented in this paper.

EVALUATION OF REPORTS

The state of Texas performs a rigorous technical review of applications for ECM grants in accordance with procedures in Reference [2]. ECM grant applications are ranked according to average simple payback, energy saved through conversion to coal or renewable energy sources, annual energy savings from implementation of ECMs, and quality of technical assistance reports. During the evaluation of the quality of the technical assistance reports at the state level, problems and errors are discovered and corrected; and occasionally, the originator of the report is requested to supply additional or revised information. A major goal of this technical review is to prepare the reports for federal-level evaluation by the DOE. Detailed evaluation of a report includes assigning numerical scores to individual ECMs and to the M&Os collectively. Corrected reports were not generally available during the compilation of data for this present report because they had been sent to DOE. However, the scores assigned to various parts of the reports were available and were used to eliminate erroneous or problematic ECM data.

For Cycle VIII of the ICP, sixty-two Technical Assistance (TA) reports were prepared and submitted by twelve independent engineering consulting firms based in seven cities: Austin, Dallas, El Paso, Houston, Lubbock, San Antonio, and Tyler. The TA reports covered buildings at fifteen school districts, five colleges, and nine hospitals, representing twenty-six cities throughout the state. There were ten high schools, eleven junior high schools, and seventeen elementary schools.

There were 330 ECMs and 220 M&Os described. Many of the ECMs had paybacks greater than ten years or less than two years; therefore, only 180 ECMs were submitted for funding as ECM grant projects. Of that number, 32 projects had significant problems in presentation, input data, or calculations and were not considered further in this compilation, although many were subsequently corrected and submitted to DOE for funding. All of the M&Os were considered for the purpose of this paper. The tabulated results are broken down into energy system categories and building types.

The review method included scoring each of the 180 ECMs recommended for funding in the TA reports, with the ECMs recommended for funding accounting for sixty percent of the score of each report. The remaining forty percent of each report score was comprised as follows: executive summary, facilities description, tables, graphs, charts, ECMs not recommended and overall report detail, (twenty percent); and consideration of M&Os, (twenty percent).

BUILDING ENERGY USE CHARACTERISTICS

In addition to energy conservation recommendations such as ECMs and M&Os, the TA reports are a source of building energy use characteristics. A tabulation of the use of electricity, natural gas, purchased steam or hot water, purchased chilled water and other fuels is required to be presented [1] for the following building systems: heating, cooling, air distribution, domestic hot water, lighting, and other. This information is given on a building basis and may be compared to metered totals. Problems with data of this type include multiple buildings on a single meter and a lack of measured data for the individual building systems. Much of the data, then, is estimated.

Buildings in this program must be considered as single units, and a TA report can cover no more than one building. Buildings which appear to be separate may be considered as a single unit if they are connected by enclosed and conditioned space.

Data in this section was compiled from information found in charts d(1) and d(2) of the TA reports [1]. Tables 1-5 contain data on energy use characteristics by the system for the following types of buildings: hospitals, elementary schools, junior high schools, high schools, and colleges. Energy utilization and energy cost indices (EUI and ECI) are given. The effect of central utility plants feeding several buildings is not considered. There was one such plant encountered (at a college) in Cycle VIII. The 9800 square foot plant had an EUI and ECI of 24.2 million Btu/SF/YR and $121.10/SF/YR, respectively, and supplied other buildings. One other facility, a central plant, was encountered within a hospital and was considered as a part of the hospital data. The energy use characteristics and other data for that hospital are similar to those of other hospitals. In all cases, energy values are based on the source. Electricity usage is converted to Btu by 11,600 Btu/KWH and natural gas is converted to Btu by 1,030,000 Btu/MCF. The average purchased electricity and gas figures from charts d(1) result in an overall cost of $0.0596/KWH (calculated by dividing the sum of the annual electric bills by the sum of the annual electrical energy used) and $4.85/MMBtu respectively. The number of facilities that have each type of system is also given in Tables 1-5, and all area averages are based on the appropriate number of facilities that contain that particular type of system.

Table 1. Energy use characteristics for hospitals. Energy use characteristics were only reported for eight hospital buildings in the TA reports.

BUILDING SYSTEM OR INDEX	ENERGY OR COST	TOTAL AREA (SF)	NUMBER OF BUILDINGS
HEATING			
(KWH/SF/YR)	0.363	1,315,000	6
(MCF/SF/YR)	0.056	1,643,000	8
COOLING			
(KWH/SF/YR)	14.6	1,643,000	8
(MCF/SF/YR)	0.351	136,700	1
AIR DISTRIBUTION			
(KWH/SF/YR)	6.84	1,643,000	8
DOMESTIC HOT WATER			
(KWH/SF/YR)	0.180	1,177,000	4
(MCF/SF/YR)	0.043	1,643,000	8
LIGHTING			
(KWH/SF/YR)	7.69	1,643,000	8
MISC. USES & EQUIPMENT			
(KWH/SF/YR)	6.41	1,643,000	8
(MCF/SF/YR)	0.026	731,700	7
ENERGY UTILIZATION INDEX			
EUI (BTU/SF/YR)	549,000	1,643,000	8
ENERGY COST INDEX			
ECI ($/SF/YR)	2.46	1,643,000	8

Table 2. Energy use characteristics for elementary schools.

BUILDING SYSTEM OR INDEX	ENERGY OR COST	TOTAL AREA (SF)	NUMBER OF BUILDINGS
HEATING			
(KWH/SF/YR)	0.577	584,600	15
(MCF/SF/YR)	0.031	561,700	13
COOLING			
(KWH/SF/YR)	3.85	624,200	17
AIR DISTRIBUTION			
(KWH/SF/YR)	2.16	610,100	16
DOMESTIC HOT WATER			
(KWH/SF/YR)	1.00	42,800	2
(MCF/SF/YR)	0.002	561,700	13
LIGHTING			
(KWH/SF/YR)	2.06	624,200	17
MISC. USES & EQUIPMENT			
(KWH/SF/YR)	0.297	624,200	17
(MCF/SF/YR)	0.002	516,000	11
ENERGY UTILIZATION INDEX			
EUI (BTU/SF/YR)	136,000	624,200	17
ENERGY COST INDEX			
ECI ($/SF/YR)	0.97	624,200	17

Table 3. Energy use characteristics for junior high schools.

BUILDING SYSTEM OR INDEX	ENERGY OR COST	TOTAL AREA (SF)	NUMBER OF BUILDINGS
HEATING			
(KWH/SF/YR)	0.212	214,000	6
(MCF/SF/YR)	0.029	325,300	7
COOLING			
(KWH/SF/YR)	2.49	383,300	11
(MCF/SF/YR)	0.021	130,600	1
AIR DISTRIBUTION			
(KWH/SF/YR)	1.75	303,200	8
DOMESTIC HOT WATER			
(KWH/SF/YR)	0.312	202,100	5
(MCF/SF/YR)	0.010	310,200	6
LIGHTING			
(KWH/SF/YR)	2.73	383,300	11
MISC. USES & EQUIPMENT			
(KWH/SF/YR)	0.043	370,600	10
(MCF/SF/YR)	0.014	27,200	2
ENERGY UTILIZATION INDEX			
EUI (BTU/SF/YR)	128,000	383,300	11
ENERGY COST INDEX			
ECI ($/SF/YR)	0.93	383,300	11

Table 4. Energy use characteristics for high schools. Energy use characteristics were only reported for ten high school buildings in the TA reports.

BUILDING SYSTEM OR INDEX	ENERGY OR COST	TOTAL AREA (SF)	NUMBER OF BUILDINGS
HEATING			
(KWH/SF/YR)	0.288	254,300	3
(MCF/SF/YR)	0.030	936,100	10
COOLING			
(KWH/SF/YR)	3.44	921,600	9
AIR DISTRIBUTION			
(KWH/SF/YR)	1.91	921,600	9
DOMESTIC HOT WATER			
(KWH/SF/YR)	0.109	254,300	3
(MCF/SF/YR)	0.010	883,600	8
LIGHTING			
(KWH/SF/YR)	2.17	936,100	10
MISC. USES & EQUIPMENT			
(KWH/SF/YR)	0.494	921,600	9
(MCF/SF/YR)	0.002	21,500	1
ENERGY UTILIZATION INDEX			
EUI (BTU/SF/YR)	133,000	936,100	10
ENERGY COST INDEX			
ECI ($/SF/YR)	0.82	936,100	10

Table 5. Energy use characteristics for college buildings.

BUILDING SYSTEM OR INDEX	ENERGY OR COST	TOTAL AREA (SF)	NUMBER OF BUILDINGS
HEATING			
(KWH/SF/YR)	0.264	678,000	8
(MCF/SF/YR)	0.052	796,000	13
COOLING			
(KWH/SF/YR)	11.6	796,000	13
AIR DISTRIBUTION			
(KWH/SF/YR)	4.86	796,000	13
DOMESTIC HOT WATER			
(KWH/SF/YR)	0.016	52,860	1
(MCF/SF/YR)	0.009	701,800	9
LIGHTING			
(KWH/SF/YR)	6.07	796,000	13
MISC. USES & EQUIPMENT			
(KWH/SF/YR)	0.825	752,100	11
(MCF/SF/YR)	0.005	360,900	5
ENERGY UTILIZATION INDEX			
EUI (BTU/SF/YR)	330,000	796,000	13
ENERGY COST INDEX			
ECI ($/SF/YR)	1.48	796,000	13

Hospitals dominate the higher values due to continuous operation of major systems. There are several other interesting aspects of the data to observe. One is that there were only two facilities which used gas as a primary energy source for cooling: a hospital (Table 1) and a junior high school (Table 3). Twelve buildings were reported as using no hot water. These included two high schools and two junior high schools. These buildings likely did not contain kitchens or field houses.

Tables 1-5 show that cooling and lighting systems use the majority of energy in the buildings considered. M&Os and ECMs which try to reduce energy consumption and control costs in these two categories should be the most attractive. Tables 2, 3, and 4 show energy use characteristics for primary and secondary schools. Of interest here is the cooling and lighting systems for junior high schools. Here, lighting consumes more energy than cooling although a large difference does not exist. The average EUIs and ECIs are all significantly close for schools. Dividing the ECI by the EUI from Tables 1-5 results in the following costs of energy per million Btu: hospitals, $4.48; elementary schools, $7.13; junior high schools, $7.27; high schools, $6.17; and colleges, $4.48. This significantly higher energy cost for elementary, junior high and high schools is not indicative of a relatively higher use of electricity.

In fact, Tables 1-5 indicate the following percentages of energy supplied to the buildings by electricity: hospitals, 46%; elementary schools, 48%; junior high schools, 36%; high schools, 40%; and colleges, 55%. Apparently, the relatively higher cost for energy in elementary, junior high, and high schools may be attributed to less favorable rate structures. This is reasonable when it is observed that they are generally smaller and therefore use less energy than hospitals and colleges where there are usually far more buildings on one meter than in primary and secondary schools. From a standpoint of cost savings, the rate structure for schools other than colleges bears examination. However, significant energy savings opportunities are to be found in the more energy-intensive hospitals and colleges.

The data in Tables 1-5 is calculated based on systems information. It is interesting to compare this data to the energy use data available from utility bills. This is done in Table 6, where the total purchased energy used in each type of building is subtracted from the calculated energy, and then divided by the calculated values. The differences are interesting, and especially so when one considers that the calculated and purchased values are supposed to be reconciled in all reports by the TA analysts [1]. Table 6 indicates that they were not. Most of the differences are perhaps unimportant; however, there are some large differences. Some of the differences were qualitatively explained (rather than reconciled) in the TA reports and come from reasons such as the following: systems (such as HVAC) brought on line after the period of time covered by the purchase records. Calculations, of course, reflect annual use of the latest configuration. In other cases, building use patterns may have changed subsequent to purchase records; and in many cases, the desired reconciliation was complicated by multiple buildings on one meter. In some cases, analysts used billing data from similar buildings.

Table 6. Percent difference between calculated and purchased energy data.

BUILDING TYPE	ELECTRICITY (%)	GAS (%)
Hospital	5	-2
Elem School	2	10
Junior High	--	--
High School	-1	2
College	-1	0.2

MAINTENANCE AND OPERATING PROCEDURES

Maintenance and operating procedures are generally described as "no-cost, low-cost" items which can be performed by maintenance employees of the school or hospital. Although no funding is available from the ICP to implement such measures, they are items which due to their low cost and ease of implementation should be so attractive that they will be accomplished by building operators soon after identification. Examples of typical M&Os include: repairing and caulking doors and windows, insulating piping and hot water heaters, reducing lighting levels or lighting operating hours, changing the temperature setting for HVAC equipment, and repairing leaks in steam systems.

A total of 220 M&Os were recommended in Cycle VIII of the ICP, and were described individually in charts e(2) and e(3) of the TA reports [1]. The implementation cost, cost savings, and payback if all 220 M&Os are implemented are shown in Table 7 by building type. The cost savings shown there can be

Table 7. Financial savings due to M&O implementation. The area used is the total area found in Tables 1-5.

BUILDING TYPE	IMPLEMENTATION COST($/SF/YR)	COST SAVINGS ($/SF/YR)	PAYBACK (YEARS)	PERCENT REDUCTION IN ECI
Hospital	0.00148	0.0479	0.031	1.9
Elem School	0.0172	0.0293	0.59	3.0
Junior High	0.0225	0.0623	0.36	6.7
High School	0.0345	0.0526	0.66	6.4
College	0.0239	0.0664	0.36	4.5

viewed as an annual reduction in the ECI values found in Tables 1-5, and the reduction is shown in Table 7 as a percentage. The total savings for all M&Os is $223,000 and the implementation cost is $73,000. The payback is 0.33 years. Energy saved is 2.2 million KWH/YR of electricity and 19,000 MCF/YR of natural gas. Table 7 indicates that hospitals are a good source of low-cost, no-cost savings because the implementation cost is less than ten percent of the schools' cost, leading to a much shorter payback.

Energy savings are shown in Table 8 by building type. The energy savings on an annual basis in Table 8 can be viewed as a reduction in the EUI values in Table 1-5. Elementary schools are a factor two or more below other buildings in energy savings from M&Os (Table 8).

Table 8. Energy savings due to M&O implementation. The area used is the total area found in Tables 1-5.

BUILDING TYPE	ELECTRICITY (KWH/SF/YR)	GAS (CF/SF/YR)	SAVINGS (BTU/SF/YR)	PERCENT REDUCTION IN EUI
Hospital	0.587	5.10	10,700	1.9
Elem School	0.314	1.07	4,490	3.3
Junior High	0.316	5.48	9,390	7.3
High School	0.318	4.68	9,060	6.8
College	0.769	4.27	13,300	4.0

Reductions in the EUI and ECI in Tables 7 and 8, while related, are not direct ratios because of the varying effect on fuels by the M&Os and varying implementation costs. Table 7 indicates that costs can be cut a significant amount (over four percent for junior high schools, high schools, and colleges) with reasonably short paybacks without requiring employment of outside personnel or contractors.

ENERGY CONSERVATION MEASURES

Energy conservation measures are generally more expensive to implement than M&Os, and thus have longer paybacks. Some ECMs which are recommended for funding and implementation are dependent upon other recommended ECMs, and perhaps upon the M&Os. All the M&Os are assumed by the analysts to be accomplished in calculating ECM savings; and similarly, the dependence of recommended ECMs such as HVAC modifications upon lighting changes is taken into account. ECMs are described individually in charts g(2) of the TA reports [1].

The 148 ECMs of all categories analyzed in this report have a total implementation cost of $2,232,000. Annual savings are $555,000, resulting in a simple payback of 4.0 years. They are estimated to save 7.3 million KWH/YR of electricity and 20,000 MCF of natural gas per year.

Table 9 shows the implementation cost, cost savings, and payback for the ECMs by category of buildings. The savings may be regarded as reductions in the ECI, and that percent savings (based on data from Tables 1-5) is shown in Table 9. Similarly, Table 10 shows energy savings due to imple-

Table 9. Financial savings due to ECM implementation. The area used is the total area found in Tables 1-5.

BUILDING TYPE	IMPLEMENTATION COST($/SF/YR)	COST SAVINGS ($/SF/YR)	PAYBACK (YEARS)	PERCENT REDUCTION IN ECI
Hospital	0.634	0.152	4.2	6.2
Elem School	0.158	0.032	4.9	3.3
Junior High	0.790	0.154	5.1	16.6
High School	0.388	0.095	4.1	11.5
College	0.535	0.172	3.1	11.6

Table 10. Energy savings due to ECM implementation. The area used is the total area found in Tables 1-5.

BUILDING TYPE	ELECTRICITY (KWH/SF/YR)	GAS (CF/SF/YR)	SAVINGS (BTU/SF/YR)	PERCENT REDUCTION IN EUI
Hospital	2.29	4.36	32,300	5.9
Elem School	0.327	0.80	4,600	3.3
Junior High	1.09	12.8	25,800	20.1
High School	0.936	3.10	14,300	10.9
College	2.55	5.48	35,300	10.7

mentation of ECMs. These tables (Tables 9 and 10) in conjunction with Tables 7 and 8, indicate that junior high schools, high schools, and colleges are very fruitful targets for both financial and energy savings. M&0s and ECMs at elementary schools are significantly lower than for other schools and colleges (at least a factor of three for both costs and energy), which may be a result of the usual neighborhood, single-story type construction of elementary schools. Junior high schools are obviously good candidates for energy savings programs, which may stem from their often being located in older buildings (sometimes former high school buildings). As expected, due to the higher implementation costs, the paybacks of ECMs in Table 9 are much larger (more than a factor of ten) than the M&0 paybacks in Table 7.

Table 11 shows energy use savings by the system in the various types of buildings due to ECM implementation. Generally, HVAC systems are the systems where most ECM saving's opportunities are found, although this is not true for each building type. In high schools, lighting presented more savings. No savings are indicated for domestic hot water at elementary schools in Table 11; yet, electricity for domestic hot water at elementary schools required about three times as much energy as at other types of facilities (Tables 1-5). Note that only two elementary schools reported the use of electricity in Table 2, and there were no ECMs suggested for the domestic hot water in elementary schools. The total use of energy for domestic hot water in the various facilities is low for elementary schools. It is as follows, in Btu/SF/YR: hospitals, 26,700; elementary schools, 2,700; junior high schools, 7,700; high schools, 8,300; and colleges, 8,600.

Table 11. Savings in BTU/SF/YR by energy use categories due to ECM implementation. The area used is the total area found in Tables 1-5.

BUILDING TYPE	HVAC	LIGHTING	DOMESTIC HOT WATER	OTHERS
Hospital	26,400	400	400	5,100
Elem School	1,500	1,200	0	1,900
Junior High	14,200	5,600	900	5,000
High School	3,000	4,700	400	6,200
College	16,700	8,700	750	9,100

ECMs that did not fall into HVAC, lighting, and domestic hot water were categorized as "other." Individually, they were relatively small in energy savings; but together, they were sometimes large. ECMs included in this summary category involve such items as the following: energy management systems and controls, steam trap renovation, separating space heating from domestic hot water, high efficiency electric motors, hot gas reclamation, and plate heat exchangers.

EVALUATION PROBLEMS

Reviews are conducted of TA reports at both the state and the federal level. The ultimate objective of these reviews is to assure that only technically correct, cost-effective conservation measures are approved for funding. The necessity and effectiveness of the review is indicated by the number of errors uncovered. Of 180 ECMs submitted for funding, eighteen percent (32) had significant problems which led to major corrections. These problems would normally be identified in any compilation of this sort and include: use of undocumented numbers (rules of thumb), sample calculations which are not clear (sometimes impossible to follow), lack of detail (particularly on cost estimation), and similar problems. Most of these can be solved by careful application of basic principles of problem solving and by writing for an audience which has been uninvolved in the audit process and may need to be able to understand the report years downstream without further correspondence.

An interesting new problem is computer program documentation. The price of hardware and software has declined within the past few years to the point that they are ubiquitous. Complicated heat-gain, heat-loss problems can be done quickly and effectively using computer analysis. However, the supplying of a useful sample calculation has become more difficult and sometimes is ignored altogether. Also, computers are sometimes used (for example in lighting problems) where hand calculations are often equally effective. A quote from the guidelines [1] states, "In general, the state does not feel that detailed computer analyses are necessary to justify most energy conservation projects. Carefully prepared, concise hand calculations based on simplified energy calculations are usually much easier to follow during the TA review process, and they provide adequate accuracy for the basic objective of a TA report." The use of hand calculations in all situations where they are easy and effective is encouraged and required. However, there are situations, such as in heat-gain, heat-loss calculations, where computer programs are extremely useful.

The problem of documentation for reviewers is a serious one, particularly where complicated programs are involved. It is a problem which has not been solved. Proposed solutions and their drawbacks include: requiring supporting hand calculations (lessens the usefulness of the computer program if a calculation is repeated and results in costly expenditure of time); qualifying the program on a standard building (arguably this has been done for commercial programs, but even so, the reviewer may not know if the data has been properly entered by the auditor): allowing the results to stand if they appear to be in a suitable range (yet answers to hand calculations which appear to be in a suitable range are sometimes obviously obtained in totally incorrect ways). This list of solutions and drawbacks is obviously not comprehensive, but it is indicative of the problem. The problem needs to be addressed with considerable intensity because it will increase as more and more computers and attendant software are used in conservation analyses.

CONCLUSION

The primary purpose of the Institutional Conservation Program is to reduce energy consumption and control the related escalating costs in state owned buildings. An overview of that program and the results of one cycle of audits in the state of Texas has been presented.

Building energy use characteristics for hospitals, colleges, elementary, junior high, and high schools were obtained, and are useful in identifying the best candidates for cost reduction and energy reduction programs. Maintenance and operation (no-cost, low-cost) and more expensive energy conservation measures were discussed. Taken together, all types of measures covered would save $778,000 annually and cost $2.3 million to implement, paying for themselves in 3.0 years. Savings in electricity and natural gas amount to 9.5 million KWH and 39,000 MCF annually, respectively. This is equivalent to about 27,000 barrels of oil.

The services of twelve independent engineering consulting firms were involved in identifying these savings in a statewide effort.

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