Energy Conservation Recommendations, Implementation Costs, and Projected Paybacks for Georgia's Targeted Schools and Hospitals Conservation Program

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ABSTRACT

During the past year the Georgia Tech Research Institute performed technical assistance studies on over 100 school and hospital buildings under a program funded by the Governor's Office of Energy Resources. This program is known as the Targeted Schools and Hospitals Program because its objective is to involve facilities which have never participated in the traditional DOE funded Institutional Conservation Program (ICP) due to economic hardships. The program was specifically directed at non-participants by providing fully funded energy surveys on qualifying facilities. The energy surveys were conducted by the Georgia Tech Research Institute under contract with the Office of Energy Resources.

This paper presents results on the range of energy conservation recommendations made and the number of occurrences in the total population as well as the typical percentage energy savings. This data can be used in forecasting the expected types of recommendations and energy reduction potential for a large population of institutional buildings.

I. Introduction

The Institutional Conservation Program (ICP) is a program to stimulate energy conservation in institutional facilities by offering cost sharing funds to implement energy efficient building improvements. This program has been active within the state of Georgia for over 10 years. In the past, the program was administered by the Governor's Office of Energy Resources and funded by the Department of Energy. Qualification for matching funds required that the institution complete a detailed engineering analysis of energy use by a certified analyst. The study, referred to as a TA report (Technical Assistance), followed strict guidelines as to content and estimation methods. Each report was reviewed by the state for content and a private contractor hired by the Department of Energy for engineering accuracy. Each institution applying for the program had to bear the cost of the TA study which averaged from $0.05 to $0.25/sf. The high cost of a TA study, lack of a certified analyst, and uncertainty of funding caused many eligible institutions not to pursue grants.

In 1987 the Office of Energy Resources conceived of a state funded program to attract previously non-participating clients into the grant cycle. Funds were made available from a portion of the oil overcharge monies returned to Georgia. The program was officially known as the Targeted Schools and Hospitals Conservation Program because its purpose was targeted to entice grant applications from previous non-participants. As an additional inducement, TA studies compiled by the Georgia Tech Research Institute were offered cost-free. This made participation by many economically disadvantaged schools and hospitals, located in primarily rural areas of the state, more likely because no up-front investment was necessary.

The energy analysis reports prepared under the targeted program were never envisioned to contain the detail of a standard TA report. They did include a description of the facility, area, energy consumption by type, baseline energy usage, Operating and Maintenance Measures (O&Ms), and Energy Conservation Measures (ECMs). Like the federal ICP program, O&Ms were to have simple paybacks generally less than 2 years and be non-capital expense items. ECMs were to be capital expense items, that are permanent modifications to the existing structure, with simple paybacks of from 1 to 15 years. Under the program the state cost shares 75% of the cost of energy related improvements up to a limit of $30,000 per building. School systems qualified for up to six separate survey reports. State matching funds were limited to a maximum of $100,000 per school system. Unlike standard TA reports, the targeted survey reports were not required to contain every possible ECM but only those considered the most feasible.

II. Building Data

This study presents the results of the analyses conducted under the targeted program. During the one-year contract period, GTRI engineers prepared 168 total energy studies. There were 19 hospitals and 149 school buildings examined. Within each broad category of schools and hospitals were several distinct building types. The table below presents a break-down of the types of buildings included in the study.

TABLE 1
BUILDING TYPES STUDIED

School Bldg.	Occurrences	%
Elementary	67	39.9
Middle	17	10.1
High	32	19.0
Vo-tech	4	2.4
Auditorium/Media	4	2.4
Cafeteria	3	1.8
Physical Ed.	20	11.9
Administration	2	1.2
Hospital Bldg.	**Occurrences**	**%**
Hospital	15	8.9
Nursing home	4	2.4
TOTAL BLDGs.	168	100.0

The majority of the buildings examined were elementary schools. They represent the largest population of buildings in the institutional sector. High schools tend to be larger, have more students and occur less frequently. The occurrence of middle schools was small because this facility is not a state wide requirement. Only a limited number of miscellaneous buildings, including cafeterias, auditoriums, and administrative offices, were studied. Physical education buildings which include gymnasiums and weight rooms were a relatively large segment because they are found at elementary, high, and middle schools. In many cases the miscellaneous functions were integrated into the larger main school facility. The type of building is a strong determinant of energy use because it has an effect on the number of operating hours, typical type of HVAC system and complexity of consumption patterns.

Area was measured or calculated for each of the facilities surveyed. It was necessary for the determination of the baseline energy usage. The building type has a substantial influence on the building area. It was noted during the study that most elementary, middle and high schools fall into a narrow range of areas, even though each building type had some small area facilities included. The small buildings result when a special purpose addition is made on the campus. Program guidelines specify a separate report must be prepared when the separate structure is of different construction and has its own utility connections.

Elementary schools were found to average 27,336 sf, and high schools, larger because of greater student bodies and more diverse course offerings, averaged 66,357 sf. Middle schools and junior highs at an average area of 32,097 fall between these two. Gymnasiums and indoor basketball facilities, when not attached to the main school building, fell into a relatively narrow range of areas. Vo-tech buildings, referred to as shop long ago, and auditorium/media centers were found to be smaller than schools, as expected, but were close to each other in average area. The smallest facilities studied were cafeterias.

Hospital buildings averaged 49,073 for the facilities examined. The small building listed in the Table is a separate Multi-purpose building at one hospital. Despite the small hospital ancillary buildings, the average size for the hospitals investigated was second only to high schools in total area. Nursing home buildings did not show the variation in size that hospitals have. The average area for the nursing homes studied was 26,602 sf. Table 2 shows a listing of area by building type. The average area is shown as are the maximum and minimum areas for each type.

Another important building characteristic that strongly influences energy use is the type of HVAC system used. Table 3 shows the percentage occurrence for electrical heat and air conditioning. Electrical heating, whether the resistance or heat pump type, was found in a large percentage of the buildings. A major justification for electrical heat in the past was the low investment cost. Buildings heated with resistance heat can show low baseline energy consumption because it has an effective efficiency of approximately 100%. If resistance heat is used the unit energy cost will usually be higher than fossil fuel heated buildings because of the high cost of electricity. More modern buildings that have electric heat generally employ heat pumps. Heat pumps, because of their high C.O.P., can display relatively low unit energy costs in addition to low energy use if they are applied correctly.

The analysis also revealed that most institutional buildings today are air conditioned. Only 9.5% of the facilities studied were found not to have cooling. Two thirds of the non-air conditioned buildings were school gymnasiums. In several instances when gyms were attached to the main building, it was also air conditioned. The number of facilities with cooling appears unusually high because a building was considered to be air conditioned if it had just one window unit. Thus, many gyms which did not have court area cooling were considered air conditioned. In the case of schools, cooling did not greatly increase the base energy use because it is not used during the peak cooling months of the summer. Cooling was almost exclusively electrical.

The two instances of buildings with gas absorption cooling were recommended to convert to electric cooling to improve the efficiency.

TABLE 2
BUILDING AREA BY BUILDING TYPE
(ft^2)

Type Bldg	Average Area	Maximum Area	Minimum Area
Elem. Sch.	27,336	58,333	4,278
Middle Sch.	32,097	73,150	4,754
High Sch.	66,357	154,721	6,319
Vo-Tech	10,183	14,210	4,540
Aud./Media	11,555	14,850	5,284
Cafeteria	8,810	14,952	4,478
Phys. Ed.	15,328	35,000	8,794
Admin.	10,900	20,600	1,200
Hospital	49,073	119,123	5,527
Nursing Home	26,602	33,518	17,960

TABLE 3
Mechanical Systems in Buildings Analyzed

System Type	Percent
Buildings w/electric heating	25.0
Buildings w/no cooling	9.5

III. Building Energy Consumption

After the area and energy usage for each building was complete, the baseline energy use can be calculated. Baseline energy use is given in Btu/sf yr, and it represents the unit energy consumption for the building. Unlike the base energy cost in $/sf yr which can give misleading notions on consumption based on the fluctuations in energy cost, baseline energy use gives an accurate portrayal of overall building efficiency.

TABLE 4
Building Energy Consumption Data

Build. Type	Base Consump. Btu/sf.yr.	Improved Consump. Btu/sf.yr.	% Reduction 33.0
Elementary	62,399	41,827	33.0
Middle	66,426	49,863	24.9
High	74,801	53,077	29.0
Phys. Ed.	68,900	44,805	35.0
Hospital	181,882	152,626	16.1

The table shows that elementary schools have the lowest baseline consumption among the five major building types. Because the consumption is given on a per square foot basis, the lower energy use is not due to these school's smaller area. The higher consumption for middle and high schools can be the result of the increased building complexity, more labs and shops, and a greater number of operating hours during the year due to more after school and summer activities. Even though physical education buildings had the greatest occurrence of non-air conditioning among those studied, their baseline energy usage ranked only behind high schools for educational facilities. This can primarily be attributed to the inherent inefficiency of this building type resulting from excessive unoccupied operation and low efficiency lighting and heating systems.

Hospitals had the highest baseline energy consumption of any building type. This was to be expected as hospitals are occupied year-round, though at varying occupancies, and they must operate complex environmental control and health care equipment.

The reports contained two types of energy savings recommendations: O&Ms and ECMs. Though the investment cost and estimated payback differ, both types of measures have the purpose of reducing building energy consumption. The projected energy consumption for each type of building and the percentage of baseline energy saved is presented in the same table. While hospitals have the highest baseline energy consumption, they also have the least potential for savings. Much of the energy used in hospitals is used to maintain strict temperature and air circulation levels in sensitive areas. The estimated energy consumption following full implementation of audit recommendations is 152,626 Btu/sf.yr. which is a savings of 16.1% over the baseline level.

The major school building types demonstrated the greatest potential for reducing baseline energy consumption. Middle schools had the lowest percentage savings at 24.9%. Elementary school audit reports contained recommendations which, if implemented, could reduce energy consumption an average of 33%. High schools at 29%

average savings fell between middle and elementary schools. Schools showed substantial energy savings because so many buildings were found to have poor envelopes, inefficient lighting and mechanical systems, and inconsistent administration.

Physical education facilities, primarily gymnasiums, demonstrated the greatest energy savings potential for the major building types. As stated above this can be attributed to the poor efficiency of gas-fired space heaters, lack of sufficient roof insulation, low efficiency of incandescent and mercury vapor lamps commonly used, and inattention to maintenance of proper temperature.

An analysis was made of the types of recommendations made for each major building group to determine their average contribution to the total savings. The results of this analysis is presented in Table 5. Generally, this table shows that most of the savings can be attributed to capital improvements or Energy Conservation Measures. These measures cost more and have longer paybacks, but they save considerably more energy. Operating and Maintenance Measures cost less and do not involve anything rigidly affixed to the building. Typical measures include fluorescent exit sign replacement, cleaning air conditioning filters, and reducing temperature setpoints. Though these measures have a low cost and short payback, they afford much less total energy savings.

ber of reports it occurred in and the percent of total reports that contained the measure.

The most frequently recommended maintenance measure was replacing incandescent lamps in exit signs with self-ballasted fluorescent retrofits. Most exit signs have two-15 or 20 watt incandescent lamps. These can be replaced with a single 7 watt fluorescent lamp. This will provide considerable energy savings and in addition will reduce maintenance costs because these lamps last up to ten times longer.

The second most common maintenance measure was the replacement or repair of air conditioning filters. Many institutional buildings have individual window units to provide cooling. During the audits conducted it was discovered that these units receive little or no maintenance attention and most have filters that are severely blocked. Regular attention to these filters can reduce the energy for cooling and increase overall comfort.

Weatherstripping was recommended in 26% of the buildings studied. Primarily the weatherstripping was for exterior doors which had significant infiltration. The most severe leaks were usually at the bottom because of excessive gaps between the door and the threshold. Most of the energy savings result from reducing winter heat loss. This loss can be corrected with weatherstripping around the edges and a scraper attached to the bottom.

TABLE 5
Percentage Savings from Different Measure Types

Build. Type	O&M Savings	ECM Savings	Total Savings
Elementary	4.7	28.3	33.0
Middle	4.7	20.2	24.9
High	3.8	25.2	29.0
Phys. Ed.	5.0	30.0	35.0
Hospital	2.2	13.9	16.1

IV. Analysis of Measures

Two general types of energy conservation measures are specified in the Technical Analysis reports: Operating and Maintenance Measures and Energy Conservation Measures. The Operating and Maintenance Measures have the purpose of returning the building to its design level of efficiency. Energy Conservation Measures are capital items that can improve the design energy consumption level of the facility, if implemented. The reports in the targeted program have been analyzed to determine what types of O&M and ECM measures were recommended most often.

The Operating and Maintenance Measures contained in the reports fell into five major categories, HVAC, envelope, lighting, domestic hot water, and miscellaneous. Table 6 presents the specific measure, num-

Energy Efficient lamps were recommended for 21% of the buildings. While many buildings have fluorescent lighting, a significant percentage are not using the most efficient lamps. If energy efficient lamps are substituted, electrical consumption is reduced 6 watts for 4 foot tubes and 15 watts for 8 foot tubes. Energy efficient lamps would not be recommended where the lighting level is marginal because there is a slight reduction in available output with these lamps. To yield an acceptable payback, replacement at burnout instead of wholesale changeout was suggested.

The fifth most recommended maintenance measure was the broad category of other HVAC improvements.

Boiler tune-ups and reducing hot water supply temperature was recommended in 15% of

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the studies. Combustion efficiency and hot water temperature were measured at each site. Despite the emphasis on proper combustion air adjustment and reducing hot

TABLE 6
Most Frequently Recommended O&M Measures

Description	# Occurrences	% of Reports
Fluorescent Exit Signs	73	43
Replace Air Filters	55	33
Weatherstrip Doors	43	26
Lower Wattage Fluorescents	36	21
HVAC-Other	34	20
Tune-up Boiler	26	15
Lower Domestic Hot Water Temp	25	15
Use Self-ballasted Fluorescent	19	11
Turn-off Pilot Lights (summer)	18	11
Lighting-Other	17	10
Adjust Indoor Thermostat	16	10

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Boiler tune-ups and reducing hot water supply temperature was recommended in 15% of the studies. Combustion efficiency and hot water temperature were measured at each site. Despite the emphasis on proper combustion air adjustment and reducing hot water temperature to the lowest practical level during the energy crisis days, much of the urgency has evidently passed as fossil fuel supply has increased and price has moderated. Devoting maintenance resources to these systems can yield energy savings dividends.

The measures replacing incandescent lamps with self-ballasted fluorescents, turning off pilot lights during the summer, and other lighting modifications were recommended in approximately 10% of the reports. Self-ballasted fluorescents are used to replace incandescent lamps when a fixture change is not warranted. Fluorescent lamps consume about 1/5 the energy of incandescent lamps of the same output. Pilot lights can be turned off in the summer in schools when the building is not in use.

The results of analyzing the Energy Conservation Measures contained in the Technical Analysis reports is presented in Table 7. The Table contains a description of the measures, number of occurrences and percentage of total reports which have the measure as a recommendation. Energy Conservation Measures were divided into three major categories: envelope, lighting, and HVAC.

Changing the type of ballasts in fluorescent fixtures was the most frequently recommended Energy Conservation Measure. Most facilities have fluorescent lights with conventional core-and-coil ballasts. Replacement with high-frequency electronic ballasts will reduce the electrical energy necessary to produce a given light output. This is a relatively new conservation development, and its market penetration is very low. Therefore, a retrofit of ballasts to save energy can be performed in most buildings. The high cost of this measure has helped limit its usage.

The second most frequent measure was replacing windows with insulating panels. The replacement panel could be brick and block, prefabricated insulating panels, or an insulated stud wall with stucco exterior. Many of the buildings audited were schools constructed in the 1950s with window walls for ventilation. Since then, these buildings have been air conditioned and the windows are no longer needed for ventilation. However, the original windows remain constituting a significant source of heat gain and loss. Replacement with an insulating panel will reduce the building's energy loss. Closely related to closing up windows is the sixth most frequent measure, installing storm windows. Complete window replacement cannot always be justified economically, and in these instances a magnetically attached storm window is recommended. A storm window affords some energy savings, primarily by reducing infiltration, at a much lower installed cost.

The third most recurrent measure was changing incandescent lighting to fluorescent. Although most building lighting was fluorescent, a considerable amount of incandescent remains. Most of it was found

TABLE 7
Most Frequently Recommended ECM Measures

Description	Occurrences	% of Reports
Change Ballast Type	69	41
Replace Windows	63	37
Convert to Fluorescent Lamps	61	36
Energy Management System	40	24
Increase Roof Insulation	37	22
Install Storm Windows	33	20
Electronic Time Clock	24	14

in kitchens, cafeterias, rest rooms, hallways, and walkways. Unlike the maintenance measure where incandescent lamps could be directly replaced, this measure involved a complete fixture changeout.

The measures occurring fourth and seventh most frequently, energy management systems and electronic time clocks, are closely related. An energy management system is installed to provide almost complete control of mechanical systems including start/stop, temperature set-back, 365 day scheduling and possibly direct digital control. Electronic time clocks were usually specified for one major system such as a boiler, furnace, or heat pump. They provide start/stop control, set-back, and scheduling. Due to their improved accuracy and flexibility, electronic time clocks to replace mechanical ones usually yield an attractive payback. Because of their complexity, energy management systems cost much more to install than time clocks.

Next in occurrence frequency was the addition of roof insulation, recommended in 22% of the buildings surveyed. Like window replacement, this measure affords savings both in summer and winter. Many of the 1950's construction school buildings which had window walls also had a roof which consisted only of a light-weight concrete deck covered with tar and gravel. The insulating value and appearance of the ceiling is improved if a suspended ceiling with batt insulation is added.

V. Economic Results for Conservation Measures

The previous section described the most frequently recommended conservation measures, both O&Ms and ECMs. This final section will present the economic results associated with each of the measures. The selection criterion for recommendation of measures was the simple payback. To be recommended an O&M measure had to have an estimated simple payback of generally less than 2 years and an ECM measure had to have a simple payback of between 1 and 15 years. This evaluation was performed because the number of times a measure was recommended was more a function of the configuration of the buildings than the economic payback.

Table 8 shows the average payback ranking for the most frequently recommended maintenance measures. Lowering the hot water supply temperature had the best payback because there is no investment associated with it, only the labor necessary to adjust the thermostat. Turning off the pilot lights in the summer had a low payback also as a result of the low investment.

Replacing incandescent lamps with self-ballasted fluorescents in standard fixtures or exit lamps yielded paybacks of just over 1 year. Tuning up the boiler and making other changes in the HVAC system both gave a 1.4 year simple payback. Retrofitting energy efficient lamps and weatherstripping had paybacks that exceeded the 2 year limit.

TABLE 8
Payback Ranking of Maintenance Measures

Rank	Description	Avg. Payback
1	Lower Hot Water Temp.	0.0
2	Turn off Pilot Lights	0.2
3	Lighting—Other	0.6
4	Replace Air Filters	0.8
5	Repl. Incandescent with Fluorescent	1.1
6	Fluorescent Exit Signs	1.3
7	HVAC—Other	1.4
8	Tune-up Boiler	1.4
9	Energy Efficient Lamps	2.2
10	Weatherstripping	2.7

They were usually recommended because weatherstripping is a relatively low cost item and energy efficient lamps can be installed at burn-out cost effectively.

The average payback ranking of the most frequently recommended ECM measures is presented in Table 9.

TABLE 9
Payback Ranking of ECM Measures

Rank	Description	Avg. Payback
1	Energy Management System	4.0
2	Electronic Time Clock	4.4
3	Convert to Fluorescent Lighting	6.4
4	Electronic Ballasts	8.5
5	Increase Roof Insulation	8.9
6	Storm Windows	9.1
7	Replace Windows	10.8

The top two measures were energy management systems and electronic time clocks. The complete EMS yielded a payback of 4 years while the partial EMS in the form of an electronic time clock had a payback of 4.4 years. Converting incandescent lighting to fluorescent had an average payback of 6.4 years. Another lighting measure, electronic ballasts, ranked fourth in average payback at 8.5 years.

The bottom three paybacks were all associated with envelope changes. Increasing roof insulation had the best payback among these measures. Storm windows have an average payback of 9.1 years which is almost 2 years less than complete window replacement. Replacing window walls with insulating panels had a payback of less than 11 years.

VI. Conclusions

The 168 institutional energy audits performed for the state of Georgia demonstrated that there is still considerable potential for conservation in this type of facility. Auditors quantified recommendations that could reduce school energy consumption by almost 1/3 and hospital by over 15%. Most of the savings can be captured by capital improvements. The best paybacks on energy related investments were found for energy management systems. Substantial savings opportunities exist for improvements in lighting and the building envelope. These measures were found to have average paybacks not greater than 11 years.