MAINTENANCE AND OPERATIONS OF SCHOOLS FOR ENERGY EFFICIENCY

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ABSTRACT

Maintenance and operations of schools with energy efficiency as a priority can reduce annual utility costs 3 to 30 percent. Most school districts do not have an organized plan for tracking energy usage or cost. Energy performance (e.g. Btu/ft^2-yr, \$/ft^2-yr) is not monitored or understood by many school administrators and board members. This paper discusses the authors 1985-86 experience and observations in accomplishing specific on-site maintenance and operations evaluations of school buildings in more than 100 Texas public school districts. The most commonly observed problems in maintaining and operating public schools for energy efficiency are presented along with successful basic methods of inspecting schools for energy efficient maintenance and operating techniques.

Maintenance and operations (M&O) of public schools represents a major part of the total lifetime building cost(Figure 1)(1). Assigning energy efficient M&O as a high priority during the initial design phase as well as during the occupied life of a school is cost effective. Our observations indicate a continuing pressure to maintain relatively constant M&O budgets in spite of continuing energy cost increases. Energy costs have increased at a rate greater than total M&O budgets, thereby leaving fewer dollars for M&O (Figure 2) (1).

There is a significant variation of energy performance of Texas public schools (Figure 3). This observation is based on our on-site evaluations and analyses. Energy performance is defined as total energy consumed (Btu's) divided by the gross square feet of area of the building (conditioned and unconditioned). Many school districts do not know the actual energy performance of their schools. In fact, different school districts evaluation of energy performance varies from no assessment of the energy bills to complex computer programs. Many of these programs have so many corrections, adjustments, and avoided cost data that the actual performance and cost cannot be readily determined or interpreted by most school administrators. Most Texas public schools need a simple method of evaluating energy cost and performance.

Usually, the utility company presents the school with a utility contract to sign. Very few school districts totally understand the rate structure which they are on and would not attempt to analyze and select the most favorable rate for their district (which can be a very complicated task). Careful evaluation of utility contracts is recommended on an annual basis and certainly anytime there is a major change in rates, building energy usage, or electrical demand. Figures 4 and 5 provide an example of determining annual energy performance for a school.

The authors have developed a computer program for PC computers to monitor energy performance and cost on a monthly basis. The program provides comparison to the previous year on a month-by-month basis. Every school district should have some tracking and evaluation method, whether it be manual or set up on a computer, to use as a management tool. The authors have also developed a computer program to analyze utility rate structures for some utilities.

Determining and tracking the energy performance of the school districts buildings is perhaps the most important step in controlling energy costs. During our investigations we detected billing errors and rate structure changes that resulted in significant savings. For example, a review of the monthly demand (KW) history at one school indicated a significant increase in KW (and cost) for a particular month. Additional analyses identified apparent meter reading errors. Unfortunately, the school paid the bill without question (which was much larger than any previous bill). A refund of \$9,025 was obtained by the school district for the overcharge. Another elementary school was observed to have a good energy performance of approximately 30,000 Btu per sq. ft. per year (site), but the average unit cost of electricity was 15.5 cents per kw-hr, approximately twice that of similar schools in the area. This alerted the energy auditor to analyze the bills and suggest a more favorable rate structure for the school. Changing rate structures on the school resulted in the district saving approximately \$22,000 per year. Another similar example resulted in a \$38,000 per year savings for a high school simply by changing to a more favorable and available rate structure.

Maintenance and operations of schools with energy efficiency as a high priority can reduce annual utility costs 3 to 30 percent. This range

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is based on our on-site evaluations of schools in more than 100 Texas public school districts. The on-site inspections and evaluations include the following M&O items.

- . Review utility bills
- . Define building energy performance
- . Conduct detail on-site inspection of building and systems (functional, physical, and operational)
- . Identify low cost/no cost M&O items to use energy more efficiently
- . Review findings with school Superintendent and/or Energy Manager
- . Accomplish analyses of M&O items identified to define energy savings and estimated cost to implement
- . Prepare formal written report for the school

The most common cost effective M&O items are:

1. Summer shutdown of unnecessary equipment (HVAC systems, lights, water coolers, pilot lights, kitchen equipment, etc).
2. Turn off lights in unoccupied areas.
3. Turn off exterior lights in daytime (manual operation; photocell control, or time clock). Reset time clock for exterior lighting for minimum allowable operation.
4. Turn off kitchen exhaust hood when cooking is complete.
5. Turn off water heaters and circulating pumps when unoccupied.
6. Program existing microprocessor to include school holidays.
7. Turn off HVAC system components (air handlers, boilers, pumps, chillers, cooling towers, etc.) when unoccupied.
8. Adjust exterior door closures for proper closing.
9. Adjust thermostats to recommended settings.
10. Reduce domestic hot water temperature.
11. Reset existing HVAC time clocks (or microprocessor) to achieve minimum daily operating hours.
12. Clean and adjust furnace and boiler burners and heat exchangers.
13. Disconnect fluorescent fixture ballasts where fluorescent lamps have been removed.
14. Change HVAC filters.
15. Clean HVAC coils (condenser and evaporator).
16. Replace/repair suction line insulation.
17. Straighten condenser fins.
18. Restrict kitchen HVAC operation to occupied times.
19. Repair gymnasium ventilation exhaust opening louvers and provide cover for winter.
20. Adjust and weatherstrip exterior doors and windows.
21. Repair HVAC supply air leaks in ducting and platform plenums.
22. Repair compressed air leaks in shop.
23. Turn off air compressor when not in use. Service air compressor and dryer for pneumatic HVAC control system.
24. Replace existing incandescent and quartz exterior lighting with high pressure sodium fixtures.
25. Disconnect football field meter when not needed.
26. Replace incandescent lighting with fluorescent.
27. Install reduced wattage fluorescent lamps and ballasts on maintenance replacement basis.
28. Insulate hot water and steam lines.
29. Repair kitchen freezer and cooler door seals.
30. Repair hot water plumbing leaks.
31. Utilize daylighting by turning off lights.
32. Eliminate any heating and cooling at same time.
33. Install backdraft dampers on all exhaust fans.
34. Instruct kitchen personnel to operate kitchen equipment in most efficient manner.

One of the most commonly observed M&O items is the summer shut-down of unnecessary equipment. As a general rule this M&O results in the most significant savings and requires only a small cost to implement. In fact, many schools have been observed to operate the HVAC system for an entire summer even though no classes are scheduled. In all of the cases observed, a reduction of HVAC and lighting in the summer could save a significant amount of both energy and dollars even if summer office work and/or summer school is held. For example, in order to decrease HVAC equipment operation one school located all summer classes in a single wing and operated only the HVAC equipment in that wing. Also, coordinating the summer class schedule with the summer cleaning schedule can result in significant savings. Benefits of this strategy are maximized for HVAC and lighting systems which can be operated in a flexible manner. Unfortunately, some schools with large central plants require the operation of several pieces of large mechanical equipment for only a few office workers. Summer shutdown in some cases has been observed to save 20 percent or more of the total annual utility costs. For some special areas, total summer shutdown is not advisable. For example, environmental conditions of high temperature and high humidity frequently require some periodic operation of cooling and/or ventilating equipment to prevent damage to acoustical ceiling tiles, wooden gym floors, laboratory materials, library materials, musical instruments, etc. In almost all applications, summer equipment operation can be reset and scheduled to save large sums of money.

Another wide variation in Texas public schools is M&O personnel. Some districts have top administrators that are highly skilled and have very organized programs. Unfortunately, many districts do not place a high priority on maintenance. Budget restraints and lack of trained personnel keep some highly skilled Maintenance director s reacting to crises rather than establishing an aggressive preventive and planned maintenance program. A problem common to many districts is that once a maintenance person has been trained and obtains valuable experience the person moves on to other non-school, higher paying jobs. Competitive salaries for good maintenance personnel are a wise investment for schools.

Energy management control systems (EMCS) are becoming increasingly popular to control the operation of air conditioning systems. Maintenance directors and school administrators are flooded with proposals with a variety of claims and costs. Considering all factors (e.g. cost, benefits, personnel, maintainability, reliability, etc.) the following types of EMCS's are recommended and have been observed to provide the most overall benefits.

- Mechanical Time Clock
- Electronic Time Clock
- Mid-Range Microprocessor EMCS

Hard wired systems are recommended for all of the above EMCS systems. For typical schools that have heating and cooling, the mid-range microprocessor EMCS with demand control is recommended. It is anticipated that future electric rate structures will be more demand based. Installed cost of these types of systems for schools range from $7,500 to $20,000. We have observed schools being quoted astronomical prices for EMCS. Prices observed have ranged from $40,000 to $200,000 for a single school.

Typical Elementary and Junior High EMCS systems should cost no more than $7,500 to $12,000 installed. For schools with up to approximately 350 students, the systems installed should cost no more than approximately $7,500, and for schools with 600 students the cost should not exceed approximately $12,000. Larger schools with up to 1,500 students may range up to $20,000. Any installed cost exceeding $20,000 for any EMCS should be reviewed with care by a Professional Engineer. All EMCS systems should be specified by an independent consultant with no financial interest in the hardware or installation. We have observed many schools where the equivalent systems with the same capabilities could have been purchased for a fraction of the cost.

CONCLUSIONS

The following conclusions/recommendations are based on our observations of maintenance and operations of Texas public schools:

1. Significant savings in energy and dollars can be achieved in almost all schools through a better M&O program.
2. Many schools do not monitor energy performance or compare costs in a meaningful manner. All schools should monitor energy cost and usage on a monthly basis and be alert for opportunities to save both energy and dollars
3. Annual rate structure analyses and evaluations of utility bills should be accomplished. Call the local utility or an independent consultant for assistance. Obtain training to accomplish in-house evaluations.
4. As a minimum, annual energy conservation M&O inspections should be accomplished for every building.
5. Retention of good maintenance personnel is a problem in many school districts.
6. There is a continuing need for training of school energy managers, maintenance directors, maintenance personnel, and school administrators.
7. Low cost/no cost energy conservation programs (such as those offered by the Public utility Commission of Texas) can be of highly significant value in the overall M&O plan for a school district.

REFERENCES

1. McClure, James D., Estes, James M., Building for Energy Efficiency. "The-Not-In-The-Red-Schoolhouse", Public Utility Commission of Texas, 1985, pp. 1,45.

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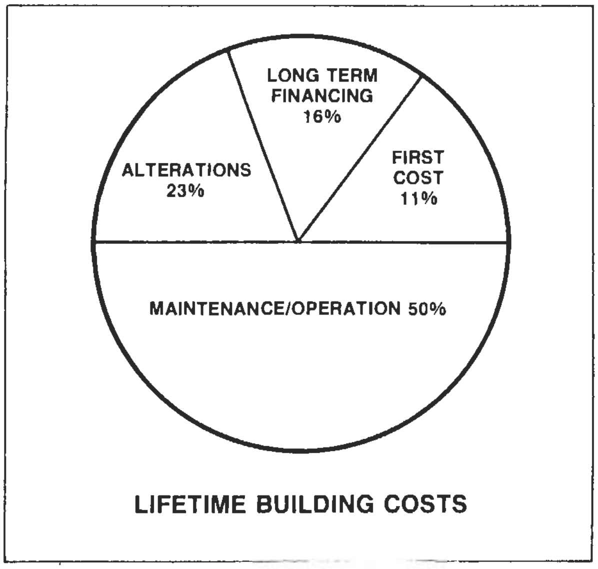


FIGURE 1 (1)

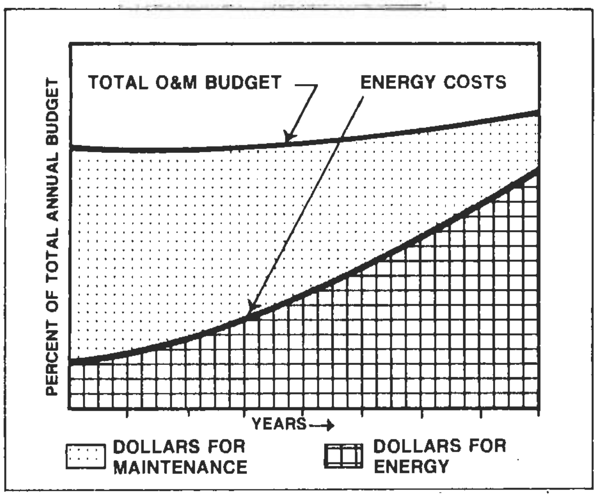
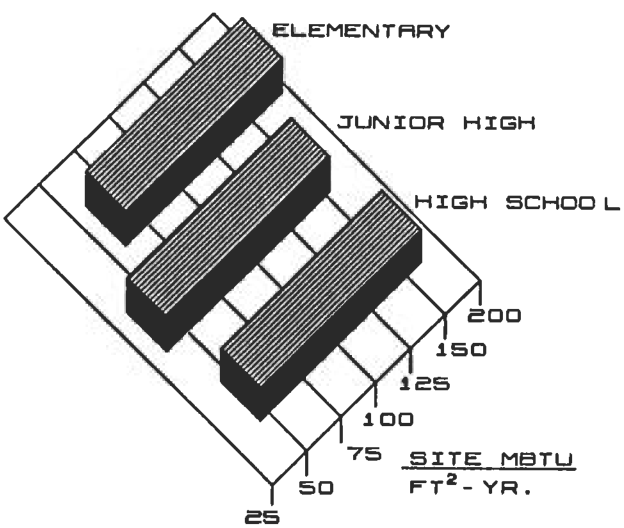


FIGURE 2 (1)



EXISTING TEXAS SCHOOLS

Figure 3

BUILDING Pine Tree Secondary School **SCHOOL YEAR** 1985(calendar)

MONTH	ELECTRICAL			NATURAL GAS		TOTAL
	KWH	KW	COST $	MCF	COST $	
JAN. 85	72,600	544	5,397	165	849	6,246
FEB. 85	103,800	530	6,383	258	1,350	7,733
MAR. 85	58,200	396	4,661	132	657	5,318
APR. 85	86,100	448	5,296	89	445	5,741
MAY 85	114,300	502	6,521	42	217	6,738
JUNE 85	58,800	454	4,640	5	33	4,673
JULY 85	54,000	272	4,594	11	66	4,660
AUG. 85	64,200	368	4,852	1	17	4,869
SEPT.85	122,700	598	7,475	24	127	7,602
OCT. 85	102,900	510	6,047	66	322	6,369
NOV. 85	96,900	466	5,618	40+	227+	5,845
DEC. 85	96,900	500	5,849	88+	481+	6,330
TOTAL ANNUAL COST	1,031,400	-	67,333	921	4,791	72,124
AVG. RATE	$/KWH = 0.065			$/MCF = 5.20		

Figure 4

ENERGY USE AND COST

ANNUAL ENERGY PERFORMANCE

BUILDING Pine Tree Secondary School **SCHOOL YEAR** 1985 Calendar **BUILDING AREA** 145,933 ft.^{2}

SITE			SOURCE		
	MILLION BTU'S			MILLION BTU'S	
TOTAL KWH x .003413	= 3,520		TOTAL KWH x .0116	= 11,964	
TOTAL MCF x 1.03	= 949		TOTAL MCF x 1.03	= 949	
	+			+	
TOTAL SITE BTU'S	= 4,469		TOTAL SOURCE BTU'S	= 12,913	
SITE TOTAL BTU'S / AREA	= 30,624	BTU'S / FT^2-YR	SOURCE TOTAL BTU'S / AREA	= 88,486	BTU'S / FT^2-YR
TOTAL ANNUAL COST / AREA	= 0.49	\$ / FT^2-YR	TOTAL ANNUAL COST / AREA	= 0.49	\$ / FT^2-YR

Figure 5