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ABSTRACT

To determine whether initial facility improvement costs were paid back by the reduced operational costs resulting from the improvement projects, this study examined the relationship between initial costs and operational costs of fourteen school buildings improved during the 1978-79 school year in Greenville County, South Carolina. With energy conservation as a goal, windows were replaced, roofs were insulated and HVAC systems were modified or replaced. Estimated annual dollar savings (from electricity payment records) were divided into the amount spent on improvement to determine the number of years required for payback. The findings indicated that ten of the fourteen buildings became more energy efficient and eight were able to pay back the initial improvement costs within their expected life span. A relationship between initial improvement costs and operational costs of school buildings was supported in that the initial costs of improvement could be repaid by the resultant reduction in operational costs. A brief review of the literature is included, which also supports these findings by showing instances of life-time savings resulting from comparatively higher initial construction costs. (Author/MLF)

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INITIAL COSTS VS OPERATIONAL COSTS

A Study of Building Improvement Projects in Fourteen Schools in the School District of Greenville County, South Carolina.

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The School District of Greenville County
South Carolina

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CONTENTS

LIST OF TABLES

1. INTRODUCTION

Increasing cost of operation and shortage of energy urged the School District of Greenville County to consider improving the physical condition of some of its existing shcool buildings which were constructed at a time when the problems of operational cost and energy shortage had not become critical. On the other hand, rapid rising costs of labor and materials in construction brought up the question of whether the money put in school building improvement would be able to pay back in a reasonable number of years.

School building improvement projects included window replacement, roof insulation and HVAC system modification, all of which were aimed at saving energy and cutting operational costs. Architects and engineers were invited to look at the design, the construction cost and the payback years in each area of building improvement. They came up with ideas which would cut down the energy consumption of school buildings and as a consequence save money. These ideas were accepted by the School District and in between April, 1978 and June, 1979, some 20 schools in the system completed their building improvement projects in the areas recommended.

PURPOSE

The purpose of this study was to examine the relationship of initial improvement costs and operational costs of school buildings included in the improvement projects.

PROBLEM STATEMENT

Could initial costs of school building improvement be paid back by reduced operational costs of shool building as a result of improvement projects?

Specifically, this study was designed to seek answers to the following questions:

1. What percentage of KWH of electricity was saved in each of the studied schools when the average monthly consumption of electricity in July-March, 1979-80 was compared to the average monthly consumption of electricity in July-March, 1977-78?
2. What estimated annual dollar amount would be saved in electricity payment in each of the studied schools when the electricity payment after the school building improvement projects was compared to the electricity payment before the school building improvement projects?
3. How many years would it take for the amount of money spent on school building improvement projects be paid back in each of the studied schools?

ASSUMPTIONS

1. It was assumed that each of the studied school buildings would have a life expectancy of 60 years.
2. It was assumed that no new light fixtures or new electrical appliances were added in each of the school buildings during the studied period.

LIMITATIONS

1. The subjects of this study were limited only to the 14 school buildings in which valid research data were available.
2. The data of this study included a nine month period before and a nine month period after the shcool building improvement projects.

3. This study was limited to its own design of a descriptive nature. Control of many variables were not possible due to the passage of time.
4. This study was limited to examining the electricity consumption as part of the operational costs in the school buildings studied.

2. REVIEW OF SELECTED RELATED LITERATURE

Selected literature relating to initial costs and operational costs of a school building has been reviewed and is reported in the following:

Zimmerman (1960) reported on a statistical analysis of the relationship of initial costs of school construction to future maintenance costs. Analytical results indicated that a relationship did exist between initial costs and maintenance cost. However, the correlation of -.46 indicated that measurements were affected by uncontrolled variables.

Educational Facilities Laboratories (1973) reported on the economy of energy conservation in educational facilities. While presenting energy conservation as the major theme, this report began and ended with life-cycle costing. Labeling the current tendency of awarding contracts on first-cost basis as a growing folly, this report stated that over a building's life-time, ill-considered economics in construction cost could prove expensive in the long run.

Roush (1973) reported on the consciousness of minimizing operating costs in the construction of three federal buildings. Bidders were requested to analyse the costs for energy required to operate the buildings for 40 years of assumed building life. The low bidder was determined by the initial construction cost plus the total energy costs.

Stephan (1975) used life-cycle costing method to analyse bids for installing an HVAC system. His example demonstrated an investment made in initially more expensive but potientially more efficient equipment. It resulted in practical savings for the school system.

Texas Power and Light Company (1977) demonstrated to builders the construction guidelines for energy-efficient home. A list of all energy-saving items with an estimated percentage of annual energy savings for each item was presented. It facilitated builders to compare initial cost with the amount of savings.

Martin (1979) examined the structure of 14 schools in Greenville County, South Carolina and recommended adding insulation, installing storm window panels and changing HVAC systems to make these schools more energy-efficient. The study also includes an analysis of initial cost and payback schedules for each renovation.

To conclude, a review of the literature reveals that the lowest initial cost may not be the most economical over the entire life-span of the building. Studies have shown instances of life-time saving as a result of a comparatively higher initial cost in construction.

3. PROCEDURE

The procedure of this study was planned to provide specific answers to the questions brought out in the first part of this report. These questions are restated in the following:

1. What precentage of KWH of electricity was saved in each of the studied schools when the average monthly consumption of electricity in July-March, 1979-80 was compared to the average monthly consumption of electricity in July-March, 1977-78?
2. What estimated annual dollar amount would be saved in electricity payment in each of the studied schools when the electricity payment after the school building improvement projects was compared to the electricity payment before the school building improvement projects?
3. How many years would it take for the amount of money spent on school building improvement projects be paid back in each of the studied schools?

RESEARCH DESIGN

The design of this study was descriptive since it was directed toward determining the nature of a situation as it existed at the time of the study.

SUBJECTS

This study involved 14 Greenville County public schools in the State of South Carolina. These 14 schools started and completed their improvement projects between March, 1978 and June 1979 in part or all of the following areas:

(1) Window replacement

(2) Roof insulation

(3) HVAC system modification/replacement

In fact, some 20 public schools in the county were involved with improvement projects in the above mentioned areas during that specific period. Valid data needed for this study were not available in six of these schools.

OPERATIONAL DEFINITIONS

Window replacement - In window replacement, 1½" metal clad polystyrene core insulative panels were installed to reduce the original glass area by 60%. These panels have an R-value of 6.25.

Roof insulation - Roof insulation as part of the whole reroofing project referred to installing 1½" of rigid insulation up the roof. Fesco foam board with an R-value of 4.16 was the material used.

HVAC system - In schools B, E, G and K, improvement in HVAC system involved modification of the self-contained units to reduce the amount of inflowing outside air.

In schools F and N, the original HVAC system was replaced by the Megatherm Thermal Storage System which was energy saving and more economical to operate.

Improvement Projects - Improvement projects in this study were limited to the energy-conservation oriented aspects of the following areas:

(1) Window replacement; (2) Roof insulation and (3) HVAC system modification/replacement.

Operational Cost - Operational costs in this study were limited only to electricity payment in the studied schools during the studied period.

SOURCE OF DATA

Year of Construction of School Building - The years of construction of the school buildings were obtained from the Office of School Facilities Planning, School District of Greenville County, South Carolina.

Life Expectancy of School Building - The life expectancy of a school building was estimated at 60 years as per suggestions made by Handler (1960).

Life Projection of School Building from 1980 - The life projection of a school building from 1980 was made by using the year of construction and the life expectancy of the school building.

Completion months of Improvement Projects - The completion months of improvement projects in each of the 14 schools were obtained from Enwright Associates Engineers, Architects and Planners, Greenville, South Carolina.

Average Monthly Electricity Consumption - The average monthly electricity consumption in each of the 14 schools for period July, 1977 to March, 1978 and period July 1979-March 1980 was obtained from the Office of Operations Accounting, School District of Greenville County, South Carolina.

Percentage of KWH Saved - The percentage of KWH saved in each of the 14 schools as a result of the improvement projects was derived from data in average monthly electricity consumption in period July 1979- March 1980 and period July 1977 and March 1978.

Estimated Annual Dollar Savings in Electricity - The estimated annual dollar savings in electricity as a result of the improvement project in each of the 14 schools was derived from information on the school electricity bills received by the Office of Operations Accounting, School District of Greenville County, South Carolina.

Amount of Dollars Spent on Improvement Projects - The amount of dollars spent on improvement projects in each of the 14 schools during the studied period was obtained from the Purchasing Office, School District of Greenville County, and Enwright Associates Engineers, Architects and Planners, Greenville, South Carolina.

Payback Years - The payback years of improvement projects in each of the 14 schools were computed from the estimated annual dollar savings and the amount of dollars spent on improvement projects.

Cost Per KWH Per Month - The cost of one KWH of electricity consumed each month in each of the 14 schools was derived from information on the school electricity bills received by the Office of Operations Accounting, School District of Greenville County, South Carolina.

TREATMENT OF DATA

Based on the raw data collected for this research, the necessary computation procedure is described as follows:

A. Average Monthly Consumption (KWH) July-March 1977-78 - It was the sum of total KWH in each of the monthly electricity bills from July 1977 to March 1978 divided by 9.

B. Average Monthy Consumption (KWH) July-March 1979-80 - It was the sum of total KWH in each of the monthly electricity bills from July 1979 to March 1980 divided by 9.

C. Percentage of KWH Saved - It was 100 times the quotient of A minus B over A i.e. $100 \frac{A-B}{A}$.

D. Cost Per KWH Per Month (July 1979 - March 1980) - The cost of one KWH of electricity per month (July 1979 - March 1980) in each of the 14 schools was computed by dividing the total amount of charges of a month by the total amount of KWH consumed in the same month. The same computation was used for all the months from July 1979 - March 1980.

E. Estimated Annual Dollar Savings - It was the sum of all D's in each school during July 1979 - March 1980 times A and then times C. i.e. $\Sigma D\ (A)\ (C)$.

F. Amount of Dollars Spent on Improvement Projects - It was the total amount spent on window replacement, retoofing and HVAC system in each of the 14 schools. The amount in reroofing only included the estimated sum of money (at 40¢ per square foot) spent on insulation.

G. Payback Years - It was the quotient of F divided by E. ..e. $\frac{F}{E}$

As an outcome of the computations, the payback year of each of the 14 schools was compared against the life projection year (from 1980) of each of these school buildings. This was to identify those school buildings in which money spent in improvement projects could be paid back within the projected life span of the school buildings.

4. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to examine the relationship of initial improvement costs and operational costs of school buildings included in the improvement projects.

The data of this study have been collected and analysed according to procedure described in Section 3. The findings, conclusions and recommendations of this study are presented in the following:

FINDINGS

1. What percentage of KWH of electricity was saved in each of the studied schools when the average monthly consumption of electricity in July-March, 1979-80 was compared to the average monthly consumption of electricity in July-March, 1977-78?

When the average monthly consumption of electricity in July-March, 1979-80 was compared to the average monthly consumption of electricity in July-March 1977-78, the percentages of KWH of electricity saved were 1.7 in School A, 26.4 in School B, 10.8 in School C, 9.1 in School D, 12 in School F, 9 in School J, 3.8 in School K, 17.4 in School L, 12.1 in School M and 8.1 in School N. Result of analyses did not indicate any savings in School E, School G, School H and School I. (See Table I)

TABLE I

Percentages of KWH of Electricity Saved

Schools	Percentage of KWH Saved
A	1.7
B	26.4
C	10.8
D	9.1
E	-
F	12.
G	-
H	-
I	-
J	9.
K	3.8
L	17.4
M	12.1
N	8.1

2. What estimated annual dollar amount would be saved in electricity payment in each of the studied schools when the electricity payment after the school building improvement projects was compared to the electricity payment before the school building improvement projects?

When the electricity payment after the school building improvement projects was compared to the electricity payment before the school building improvement projects, the estimated annual dollar amount saved in electricity payment would be 102.19 in School A, 4120.95 in School B, 1300.42 in School C, 1837.59 in School D, 4845.33 in School F, 620.65 in School J, 725.40 in School K, 2941.33 in School L, 1049.58 in School M and 6136.46 in School N. Results did not show any dollar savings in School E, School G, School H and School I. (See Table II)

TABLE II

Estimated Annual Dollar Savings

School	Estimated Annual Dollar Savings
A	102.19
B	4120.95
C	1300.42
D	1837.59
E	-
F	4845.33
G	-
H	-
I	-
J	620.65
K	725.40
L	2941.33
M	1049.58
N	6136.46

3. How many years would it take for the amount of money spent on school building improvement projects be paid back in each of the studied schools?

Data analyses indicated that for the amount of money spent on school building improvement projects to be paid back, it would take School A 102.3 years, School B 3.8 years, School C 8.4 years, School D 16.3 years, School F 17.2 years, School J 43.4 years, School K 2.1 years, School L 5.8 years, School M 29.3 years and School N 13.6 years. Results in analyses showed that the amount of money spent on improvement projects in School E, School G, School H and School I was not able to be paid back within the projected life-span of the school buildings. (See Table III)

TABLE III

Payback Years of School Building Improvement Projects

Schools	Number of Payback Years
A	102.3
B	3.8
C	8.4
D	16.3
E	-
F	17.2
G	-
H	-
I	-
J	43.4
K	2.1
L	5.8
M	39.3
N	13.6

ADDITIONAL FINDINGS

Serendipitious findings relevant to this study but not stated as questions included:

1. School A, School C and School L had the same roof insulation improvement, but as a result, School A only saved annually 1.7% of electricity consumption while Schools C and L saved a whole lot more being 10.8% and 17.4 % respectively.
2. There were examples in the study showing improvement projects of the same type done in two different schools. One ended up in energy saving while the other one did not save at all. These examples are tabulated in the following:

Schools	Improvement Projects			Results
	Window	Roof	HVAC	
D	X	X		S
M	X	X		S
I	X	X		NS
B	X	X	X	S
E	X	X	X	NS
J	X			S
H	X			NS
K			X	S
G			X	NS

Table IV - Results of School Building Improvement Projects,

S = Saved energy

NS = Did not save energy

For further research of the problem a review of design, installation and management phases of the building improvement projects is suggested.

CONCLUSIONS

As a result of data analyses, the following points could be concluded:

1. After the school buildings had been improved, 10 out of the 14 schools studied became more energy efficient.
   a. The percentage of KWH of electricity saved varied from 1.7 in School A to 26.4 in School B. (See Table I)
   b. The estimated annual dollar savings varied from 102.19 in School A to 6136.46 in School N. (See Table II)
2. Out of the 14 schools studied, 8 schools were able to pay back the initial improvement costs within their expected life spans. (See Table V)

To summarize, findings cited in this study basically supported the statement that initial costs of school building improvement could be paid back by reduced operational costs of school buildings as a result of improvement projects done to school buildings. A relationship between initial improvement costs and operational costs of school buildings has been supported.

TABLE V

Payback Years VS Life-Projection of School Buildings

Schools	Payback Years of Improvement Projects	Life Projection of School Building From 1980 (Years)
A	102.3	37
B	3.8	49
C	8.4	21
D	16.3	36
E	-	48
F	17.2	48
G	-	49
H	-	40
I	-	40
J	43.4	15
K	2.1	45
L	5.8	44
M	29.3	38
N	13.6	50

NOTE: The architect's estimated payback years were not used to compare with the payback years calculated from nine months experience. (July-March, 1979-80) because the architect's estimated payback years were based on the total amount of dollars in the improvement projects while this study only included the amount spent on energy conservation.

RECOMMENDATIONS FOR FURTHER STUDY

1. An extensive study of the same type to include more schools for a longer period of obervation is recommended. In so doing, the relationship of initial cost and operational costs could be seen in wider scope.
2. To see the relationship of initial costs and operational costs of school buildings in greater depth, an experimental study is recommended. The design of an experimental study enables provision of greater control over related variables.

APPENDIX

Table VI - Summary of Major Statistics

School Building				Completion Month of Improvement Projects			Average Monthly Consumption (KWH)		Percentage of KWH Saved	Estimated Annual Dollar Savings	Amount of Dollars Spent on Improvement Projects	Payback Years
Identification	Year of Construction	Life Expectancy (Year)	Life Projection from 1980 (Year)	Window	Roof	HVAC System	July - March 1977-78	July - March 1979-80				
A	1957	60	37	——	6-1978	——	10223	10051	1.7	102.19	10,452	102.3
B	1969	60	49	4-1978	9-1978	6-1978	33354	24560	26.4	4120.95	15,618	3.8
C	1941	60	21	——	6-1979	——	17918	15985	10.8	1300.42	10,890	8.4
D	1956	60	36	8-1978	5-1978	——	18492	16815	9.1	1837.59	29,920	16.3
E	1968	60	48	4-1978	4-1978	6-1978	13812	16693	——	——	12,668	——
F	1968	60	48	——	——	9-1978	98965	87072	12.	4845.33	83,500	17.2
G	1969	60	49	——	——	6-1978	18447	18707	——	——	360	——
H	1960	60	40	4-1978	——	——	13172	14153	——	——	18,887	——
I	1960	60	40	6-1978	6-1978	——	5505	6000	——	——	13,911	——
J	1935	60	15	12-1978	——	——	11728	10675	9.	620.65	26,948	43.4
K	1965	60	45	——	——	6-1978	38800	37312	3.8	725.40	1,490	2.1
L	1964	60	44	——	6-1979	——	29972	24771	17.4	2944.33	17,050	5.8
M	1958	60	38	5-1978	3-1979	——	14752	12966	12.1	1049.58	30,766	29.3
N	1970	60	50	——	——	6-1979	210441	193474	8.1	6136.46	83,500	13.6

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