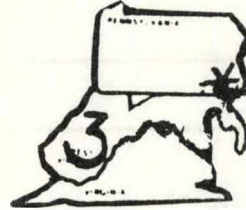


PUBLIC SCHOOLS  
ENERGY CONSERVATION  
MEASURES



Report Number 3

EVERITT ELEMENTARY SCHOOL  
Langhorne, Pennsylvania

FLACK & KURTZ

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Prepared For The  
FEDERAL ENERGY ADMINISTRATION

By  
AMERICAN ASSOCIATION OF SCHOOL ADMINISTRATORS

Contract CR - 04 -60711 - 00

The views and conclusions contained in the document are those of the authors, and should not be interpreted necessarily representing the official policies of the U. S. Government.

January 24, 1977

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## MANAGEMENT SUMMARY

Samuel Everitt Elementary School  
Langhorne, Pennsylvania

A thorough and comprehensive engineering analysis of ten representative elementary schools across the nation was undertaken to identify cost-effective energy conserving opportunities. The reports of these studies are designed to provide school administrators, engineers, architects, and associated technical personnel with indicators of potential energy savers in similar buildings. The following information is a summary of one of these ten reports.

Everitt is representative of a 1950's building with two additions located in a 3,000-6,000 degree day climate.

### BUILDING CHARACTERISTICS

#### Size:

49,314 sq.ft.  
24 classrooms, library, serving kitchen, conference rooms,  
multipurpose and administration areas

#### Occupancy:

559 students, K-5  
School day: 9:00 a.m. to 3:00 p.m.  
School year: Early September to mid-June  
After hours/summer: 6:30 p.m. to 10:30 p.m.: 5 nights per week.  
Office area used entire summer

#### Construction:

Original structure (1954) and two additions (1958, 1967);  
all have similar construction.  
Walls: 4" face brick, air space, 8" concrete block with  
45% single pane casement glass.  
Roof: Built up over 3½" Insulrock supported by exposed steel  
beams with skylights in corridors.

#### Heating, ventilation, and cooling:

Unit ventilators used throughout. Heated by (2) oil-fired  
hot water boilers.  
Cooled by 5.5 ton roof top air conditioning unit for new  
addition office area; controlled by 7 day time clock. 2 window  
air conditioning units are in library; controlled manually.

#### Illumination:

Fluorescent: 1.5 watts/sq.ft.  
Multipurpose area has (12) 500 watt mercury vapor lamps  
Exterior security has 1100 watts mercury vapor lamps

Energy Consumption and Cost:

Year	Oil			Electricity		
	Gals	Gals/sq.ft.	DD	Cals/DD	KWH	KWH/sq.ft.
1973-74	34,751	.70	4,452	7.8	163,740	3.31
1974-75	33,047	.67	4,594	7.2	159,950	3.23
Cost:	\$0.337/gal.			Cost:	\$0.048/kwh	

ENERGY CONSERVING RECOMMENDATIONS

The following recommendations are made for an existing building with the characteristics described above. They offer guidelines for analyzing buildings with similar characteristics; however, suggested energy conserving opportunities must be weighed in terms of the fuel used, its cost and associated savings as well as capital expenditure considerations. While it is not the primary intent of this report to address new construction concerns, the findings do have implications for such work.

Only ECOs that were found to be cost-effective are recommended. "Cost-effective" is defined as recovering the capital investment in 12 years or less from the anticipated energy saved. The following ECOs were recommended at Everitt:

- o Reduce outside air intake  
--500 cfm to 175 cfm as per State guidelines
- o Replace boilers with modular hot water boilers

SUMMARY TABLE: Recommended Energy Conserving Measures at  
Everitt Elementary School, Langhorne, Pennsylvania

ECGs	Estimated Cost	Recovery Rate
1. Reduce outside air	\$ 1,200	2 yrs.
2. Replace boilers	20,000	11 yrs.
ALL RECOMMENDATIONS	\$21,200	7 yrs.

## OTHER CONSIDERATIONS

The above recommendations and calculations were based on \$0.337/gal escalated at 10% per annum with 6.8% interest. As the cost of fuel exceeds this rate, other ECOs may become cost-effective and should be reviewed. Any reconsideration should not view adjusted energy and dollar savings in isolation; materials, labor, interest rates, etc. must also be assessed. The following ECOs may warrant future review:

double glazing to Clearstory glass and skylights, or paneling over Clearstory glass.

Finally, it should be noted that in a free market availability is reflected in cost. However, fuels have not had such a history. As long as fuel costs or supplies are in any way regulated, actual fuel availability should be part of retrofit considerations. The availability may transcend the cost-effective characteristics of a modification.

## PREFACE

The plight of the public schools in the face of rapidly depleting energy resources and escalating energy costs has been a matter of concern to the Federal Energy Administration (FEA) and other government agencies, as well as organizations such as the American Association of School Administrators (AASA). Reports have been published outlining the problems of energy usage in public schools, its impact on school budgets and possible ways to reduce energy consumption in existing buildings. More substantive information is needed to assist school administrators and federal energy/education decision makers in identifying specific cost-effective remedies to existing school buildings.

The schools of America consume eleven percent of the space heating/cooling energy. Over fifty percent of the schools now in use were built in the post World War II "baby boom" when first cost was far more important than energy efficient buildings. A recent FEA report revealed that energy costs to the schools increased 48.3% in a two year period (1972-73 to 1974-75). The continued escalation of energy costs coupled with energy inefficient buildings and exacerbated by general inflation has created a critical problem for the schools.

Since it has been estimated that nearly fifty percent of the space heating/cooling energy consumed by the schools is wasted, it is also a grave problem for our nation. The 1975 Congressional report on energy noted that the most economical, accessible way to "gain" fuel reserves is to reduce consumption.

School people want to reduce this waste and unnecessary expenditure. The development and dissemination of information which will enable school

administrators to identify and analyze energy conserving opportunities in existing buildings is badly needed. It is critical that school people have access to the options available to meet identified energy needs, their respective costs, and the associated energy savings.

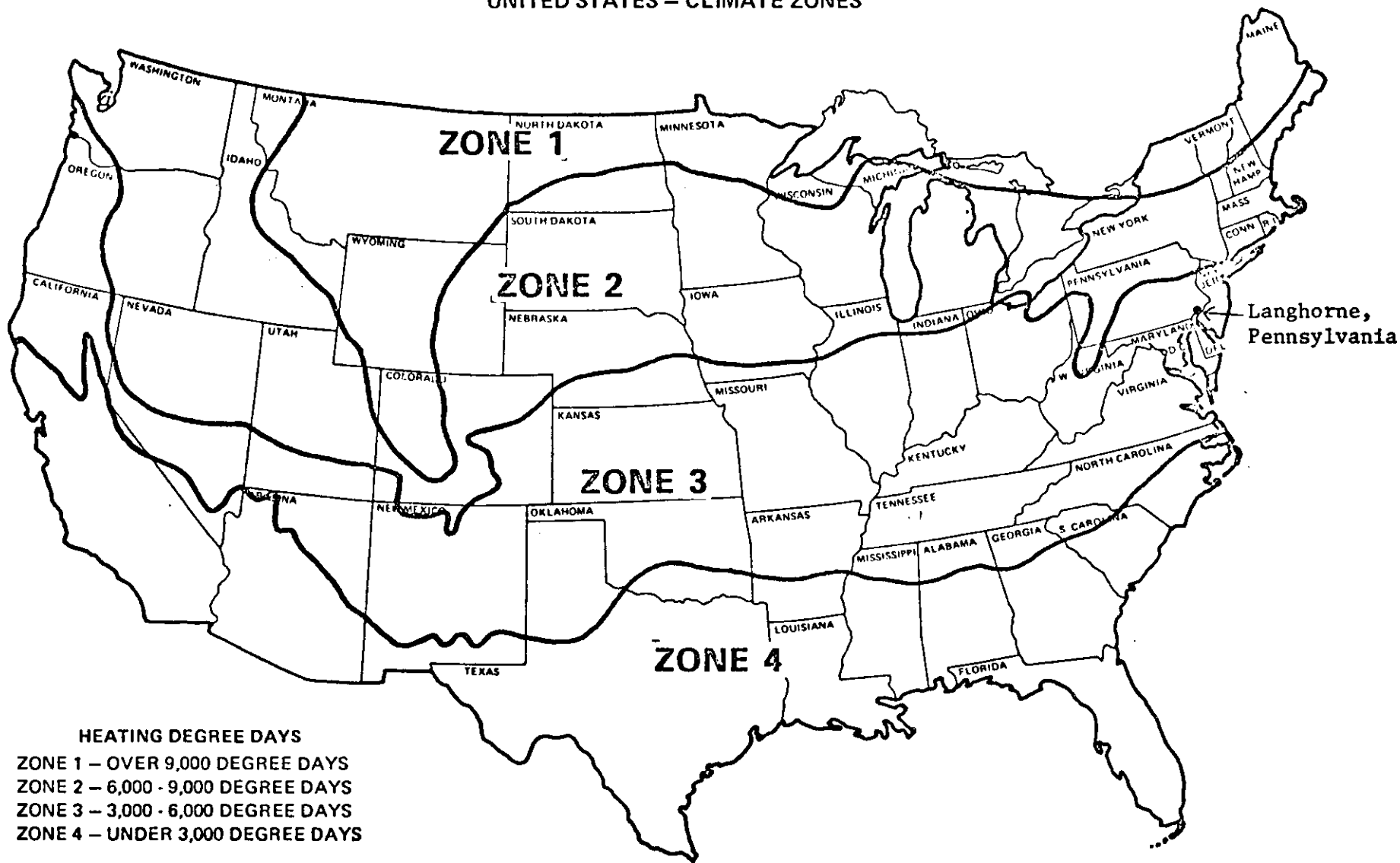
In order to provide such guidelines and to demonstrate the desirability of retrofiting existing school buildings, AASA initiated the project Saving Schoolhouse Energy. The emphasis in this study was placed on the cost effectiveness of capital modifications utilizing "off-the-shelf-hardware." The project was designed in five phases: (1) select ten elementary school buildings and analyze their energy conserving opportunities; (2) undertake needed architectural or engineering design work; (3) install or construct recommended modifications; (4) monitor and record post-modification energy use; and (5) disseminate the findings.

Phase 1, selection of the ten demonstration sites and an engineering analysis of energy conserving opportunities for each, was funded by the Federal Energy Administration.<sup>1</sup> This report for Samuel Everitt Elementary School in Langhorne, Pennsylvania, represents the culmination of Phase 1 for one of these sites and is one of ten (10) such reports. The map on page iv depicts its geographic and climate location. Other sites in the study were Harold C. Scott Elementary School, Warwick, Rhode Island; Central Elementary School, Glen Rock, New Jersey; Hindman Elementary School, Hindman, Kentucky; Fairmoor Elementary School, Columbus, Ohio; P. F. Brown Elementary School, Lubbock, Texas; Eastridge Elementary School, Lincoln, Nebraska; Garfield Elementary School, Sioux Falls, South Dakota; Plover Whiting Elementary School, Stevens Point, Wisconsin; Washington Elementary School, Kennewick, Washington.

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1. Federal Energy Administration Contract CR-04-60711-00, April 20, 1976.

# UNITED STATES – CLIMATE ZONES



Under this first phase, ten elementary school buildings were selected, one from each federal region, with the exception of Region 9. Because the criteria established for selection could not be met by any of the applicants or any of the other Region 9 schools which AASA identified through a cooperative search with the respective state departments of education, this region was omitted and, instead, a second school was selected in Region 5 to represent the northern portion of that area. Criteria used for selection of the demonstration schools included: type of structure, predictably consistent usage patterns after modifications, building longevity, building size, student enrollment, available energy consumption data, and expected energy savings as predicted through the use of the Public School Energy Conservation Service (PSECS)<sup>2</sup> computer program. It is important to note that every effort was made to find typical schools, not "bad examples"; for experience has shown "energy and dollar saving retrofit opportunities exist at even the most well maintained facilities."<sup>3</sup>

After the sites were selected, a thorough and comprehensive investigation of energy conserving opportunities for each building ensued. In this study, the PSECS material, the TRACE<sup>4</sup> or Ross Meriwether<sup>5</sup> computer programs, as-built drawings, and on-site surveys were the basis for the engineering judgment as to feasible energy conserving measures to be recommended. Such recommendations considered: (a) changes in HVAC or lighting systems or equipment, including controls; (b) modification in operations; (c) structural

- 
2. PSECS was developed by the Educational Facilities Laboratories, Inc. under a Federal Energy Administration Contract.
  3. Identifying Retrofit Projects for Federal Buildings, p. 2.
  4. TRACE computer program 200 developed by Trane Company.
  5. Meriwether ERE computer program.

changes; (d) estimated cost(s) of implementation; and (e) estimated energy savings that are expected to accrue. In addition to their engineering feasibility, the recommendations also considered the possibility of significant cost benefit, educational desirability, and environmental acceptability.

Phase 1 of the Saving Schoolhouse Energy project was completed under the auspices of AASA's Office of Governmental Relations. JCox Associates served as AASA's consulting engineer and coordinated the ten separate studies, in addition to conducting the investigation for one site.

A project of this magnitude requires the contributions and cooperation of many. The team assembled by AASA for Phase 1, PSECM # 3, Samuel Everitt Elementary School include the following firms and individuals:

Project Director: Shirley J. Hansen, AASA

Asst. Project Director: Charlotte Friedman, AASA

Coordinating Consultant: JCox Associates  
Vienna, Virginia

James R. Cox, P.E.  
Leland Eisenhower, P.E.

Engineer: JCox Associates  
Vienna, Virginia

We would be remiss if we did not also acknowledge the fine cooperation and assistance we have received from Michael Pulscak and Faith Lambert of FEA and from Edward Stephan during his tenure at FEA.

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## REPORT NUMBER 3

### SAMUEL EVERITT ELEMENTARY SCHOOL

#### 1.0 INTRODUCTION

The purpose of this study, prepared for the American Association of School Administrators, is to identify and evaluate energy conserving measures for the Samuel Everitt Elementary School. This analysis is phase one of a five phase program directed toward reducing energy consumption in existing public schools.

The AASA program will be conducted in the following five phases:

1. Evaluation and selection of ten school buildings for analysis of potential energy conserving modifications.
2. Preparation of architectural and engineering specifications and drawings for the recommended modifications.
3. Installation and construction of the modifications.
4. Monitoring and evaluating energy use after modifications, and development of energy conservation data.
5. Dissemination of the information to school districts and others interested in energy conservation.
6. Identification of institutional and financial barriers to retrofitting existing school buildings for energy conservation.

Samuel Everitt Elementary School is one of ten representative schools selected from each of the Federal Energy Administration regions. This report summarizes the results of the field investigations, computer simulation and evaluations of the energy conserving opportunities available in this school.

The emphasis in this study was on cost-effective capital investments for energy conservation. The recommended capital investments in this type of study should not be implemented without first having undertaken a comprehensive operational and maintenance program. This implies that sound energy management procedures is a continuing function and should include scheduling characteristics, periodic inspection and routine maintenance responsibilities. It further implies that the human element (faculty and students) is cooperative and appreciative of the intent of the function desired.

The identification and evaluation of energy conservation measures which could be employed in the Samuel Everitt Elementary School was performed in four steps:

- I. Site Visitation and Data Collection
- II. Computer Simulation
- III. Identification of Energy Conservation Measures
- IV. Economic Analysis

Step I involved visiting the school to obtain utility bills, architectural and engineering drawings, operating and occupancy schedules, and field measurements of existing conditions; i.e., ventilation air quantities, and space temperatures. The field measurements were performed to compare the actual mode of operation of the building system to the original design intent.

In Step II the collected data was utilized to model the subject school on a computer. The results of the computer program were compared to the actual energy consumption of the school to insure compatibility of the computer model and the real school. The "Meriwether" computer program was used for this purpose.

In Step III, the computer results were analyzed to determine the energy requirements of the building parameters which constitute the total annual energy consumption of the building; i.e., ventilation air, walls. In addition, retrofit measures which appeared to have an energy conservation impact were identified at this point.

In Step IV, the annual energy savings and the first cost to implement each energy conservation retrofit measure were determined. These costs were compared based on present fuel costs, including a fuel escalation factor and present bond rates, applicable to Samuel Everitt Elementary School, to determine the payback periods (cost-effectiveness) of each item.

### 3.0 BUILDING DESCRIPTION

Samuel Everitt Elementary School at 20001 Old Lincoln Highway, Langhorne, Pennsylvania 19407, is located in Federal Energy Administration Region No. 3. The original 1954 building had two additions which increased the total building area to 49,314 square feet. The present occupancy is approximately 559 pupils from kindergarten through 5th grade.

#### 3.1 ORIGINAL BUILDING

The original building is a one-story structure with 20 classrooms, a multi-purpose room and a kitchen (see Floor Plan, Figure 3.1). The walls are constructed of 4" face brick, air space and 8" concrete block; no insulation is provided. The heat transfer factor ('U' value) for this type wall is .30 BTU/Hr.sq.ft. degrees F. (Values obtained from "ASHRAE Guide, Handbook of Fundamentals"). Figure 3.2 shows the northwest entrance with the double height multi-purpose room at the left.

The windows are single pane casement type and have a 'U' value of 1.13 BTU/Hr. sq.ft. degrees F. Windows are provided at the perimeter of each classroom and in a clear story above the interior corridors. The windows are approximately 45% of the total building exterior wall area. Figure 3.3 shows the windows at the clear story above the corridors.

The roof is constructed of built-up roofing over 3-1/2" of insulrock and is supported by exposed steel "I" beams. The 'U' value for this type roof is .10 BTU/HR sq. ft. degrees F. Skylights are provided in the corridor roof to provide natural light. Figure 3.4 shows the roof with typical skylights above the corridor. Figure 3.5 shows a typical classroom with exposed joists supporting the roof. Figure 3.6 shows an interior view of the main entrance.

#### 3.2 ADDITIONS

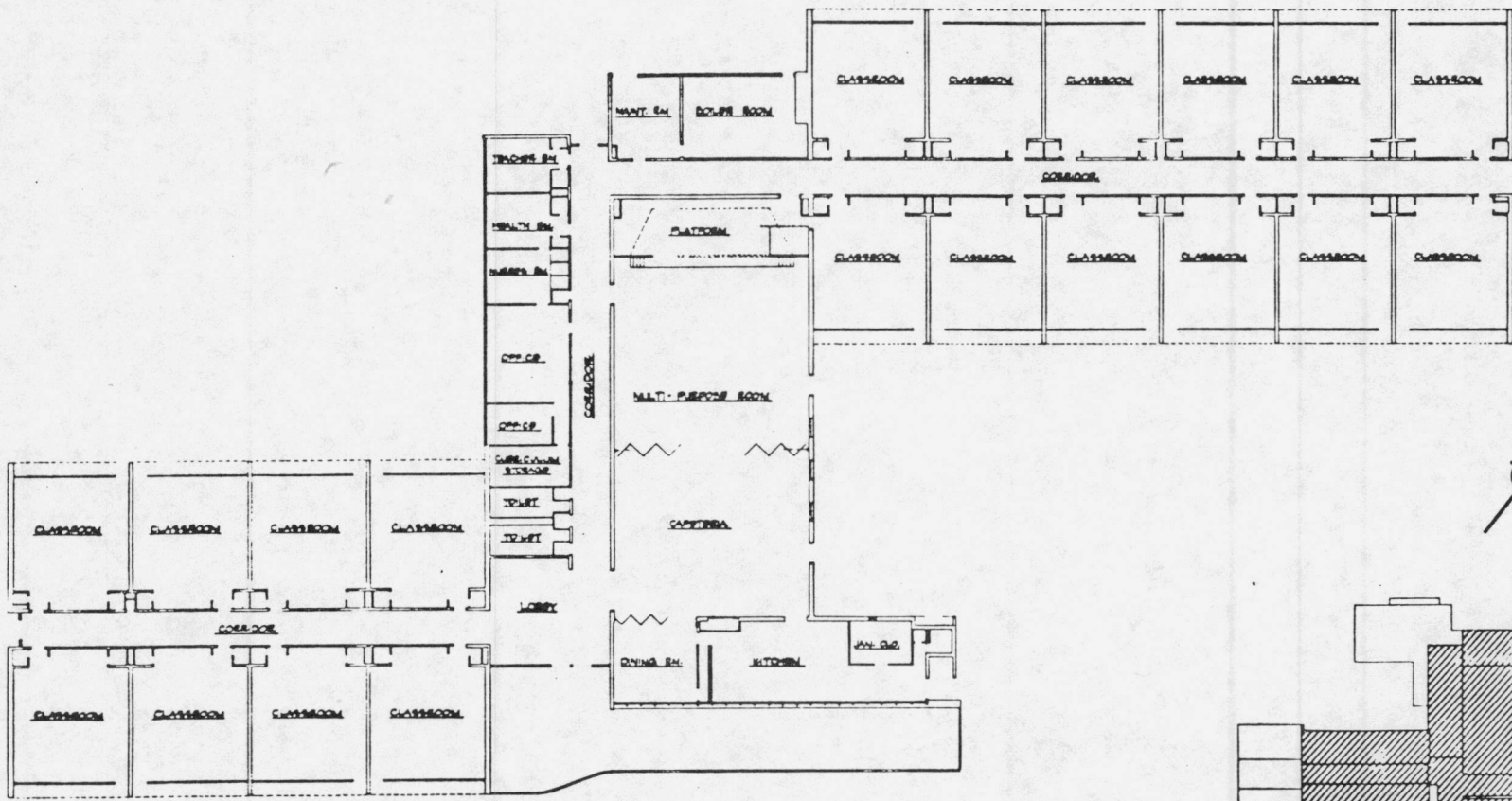
The 1967 addition (see Floor Plan, Figure 3.2) consists of a music room, library and offices and is of similar construction to the original building. The 1958 addition (see Floor Plan, Figure 3.2) consisted of four classrooms and is also of similar construction to the original building. Figure 3.7 shows the 1967 addition with the music room in the center of the photo and the library at the far right.

#### 3.3 OCCUPANCY SCHEDULE

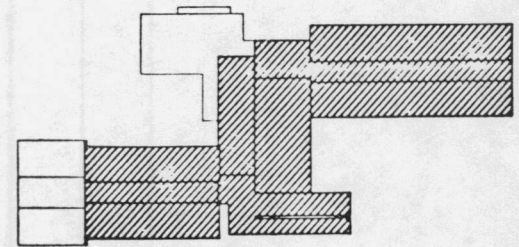
Classes are held 9:00 a.m. to 3:00 p.m. from early September to mid-June and the building is utilized five nights per week from 6:30 p.m. to 10:30 p.m. The office areas are used during the entire summer.

#### 3.4 HEATING, VENTILATING & AIR CONDITIONING SYSTEMS

The heating plant consists of two oil-fired 2,700 MBH output heating water boilers which have an estimated seasonal efficiency of 55%.



FLOOR PLAN



KEY PLAN

FIGURE - 3.1  
ORIGINAL BUILDING



FIGURE 3.2



FIGURE 3.3



FIGURE 3.4



FIGURE 3.5

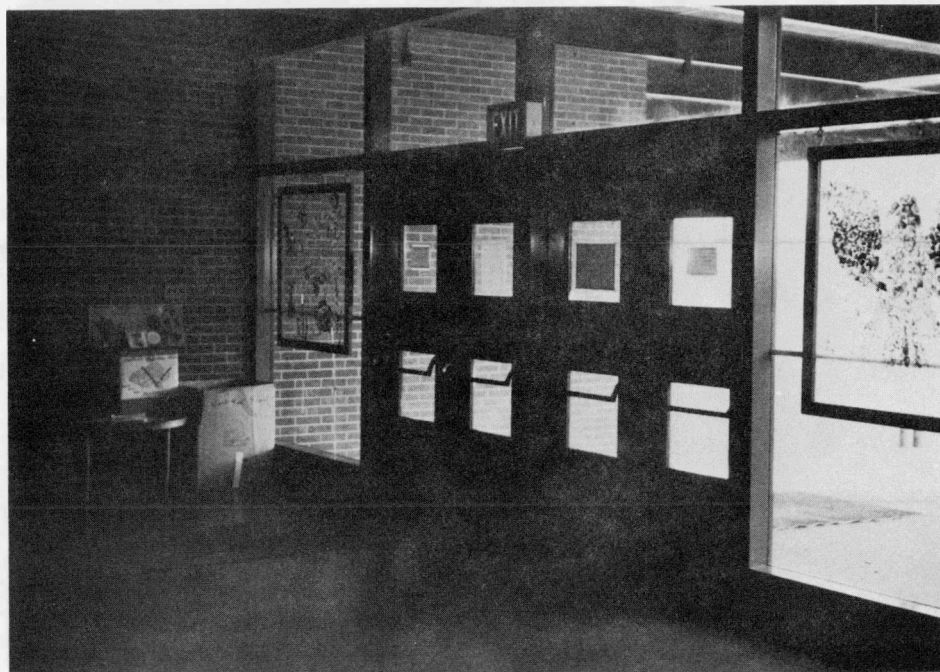
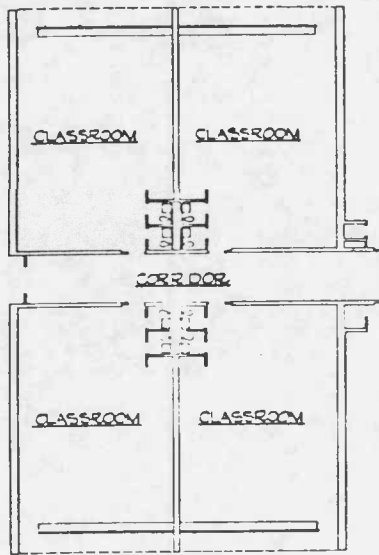
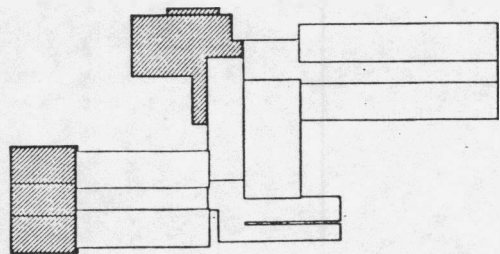


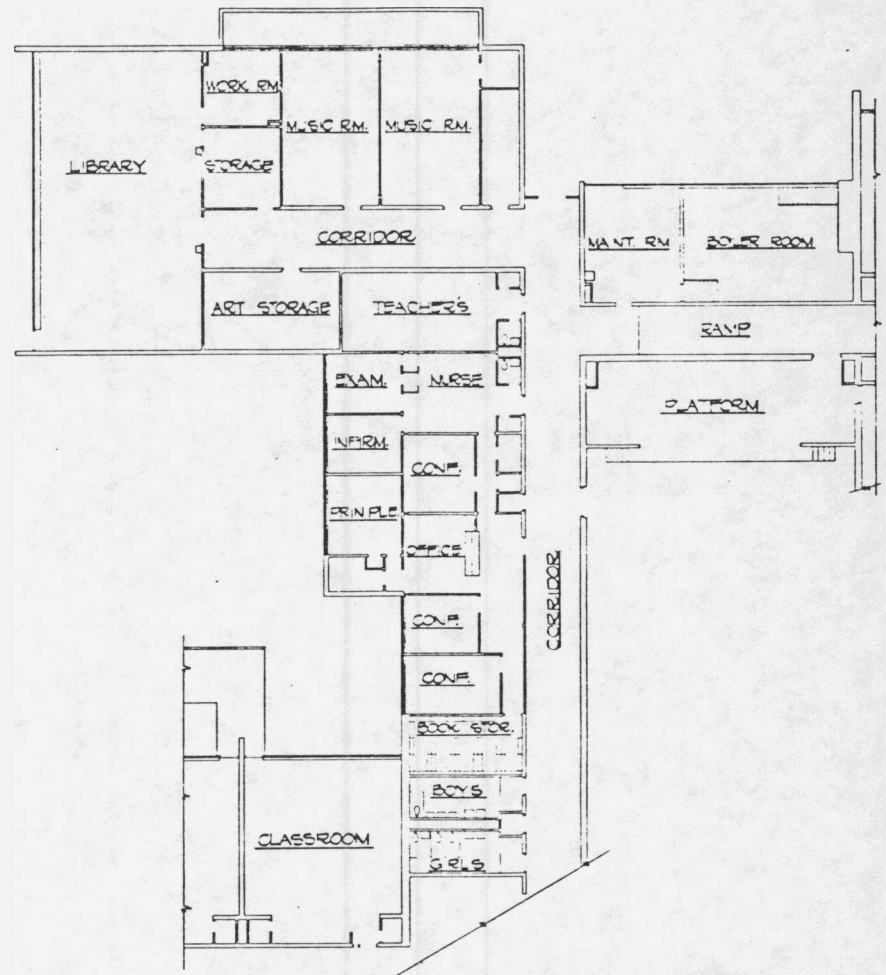
FIGURE 3.6



FLOOR PLAN



KEY PLAN



FLOOR PLAN

FIGURE - 3.7  
ADDITIONS

Return water flows through the boilers in parallel and is heated to 200 degrees F. Hot water supply temperature, scheduled with outdoor temperature, is reset by three-way mixing valves for three building zones -- classrooms, offices and new addition offices. Three circulating pumps (one standby) which are manually started circulate water through the system. Figure 3.8 is a schematic of the heating plant. Unit ventilators and radiators which provide for classroom heating are designed to operate as described below:

1. During Occupied Cycle - The fan runs continuously. The heating valve at the unit ventilator is closed, the outside air damper is open 50% and the radiator valve is open 100%. As room temperature decreases, the unit ventilator valve gradually opens from its closed position to full open. If space temperature does not rise to the thermostat setting, the outside air damper is gradually closed. If space temperature rises above the thermostat setting, the outside air damper gradually opens from 50% to full open and the radiator valve simultaneously closes.
2. During Unoccupied Cycle - The heating coil valves are 100% open, the outside air dampers are fully closed and the unit ventilator fans cycle to maintain space temperature.

A 5-1/2 ton rooftop air conditioning unit provides ventilation and cooling for the new addition office areas. Two window air conditioning units provide cooling for the library. The office air conditioning system is controlled by a seven-day time clock and the library units are manually controlled.

Multi-purpose room heating and ventilating is provided by (2) 3500 cfm unit ventilators and (1) 4500 cfm unit ventilator. Their operation is similar to the control description of the classroom unit ventilators.

The kitchen is exhausted by a 4500 cfm exhaust fan which is located in an adjacent storage room and is manually controlled.

### 3.5 ELECTRICAL SYSTEM

Lighting in the classrooms is provided by exposed fluorescent tubes hung from the structural steel supports for the roof. The typical classroom lighting level including ballasts is 1.5 watts/sq.ft. Figure 3.5 shows a typical classroom with exposed fluorescent fixtures.

The exterior security lighting is provided by 1100 watts of mercury vapor lights which are controlled by light sensors.

The multi-purpose room has (12) 500-watt mercury vapor lamps to provide for illumination.

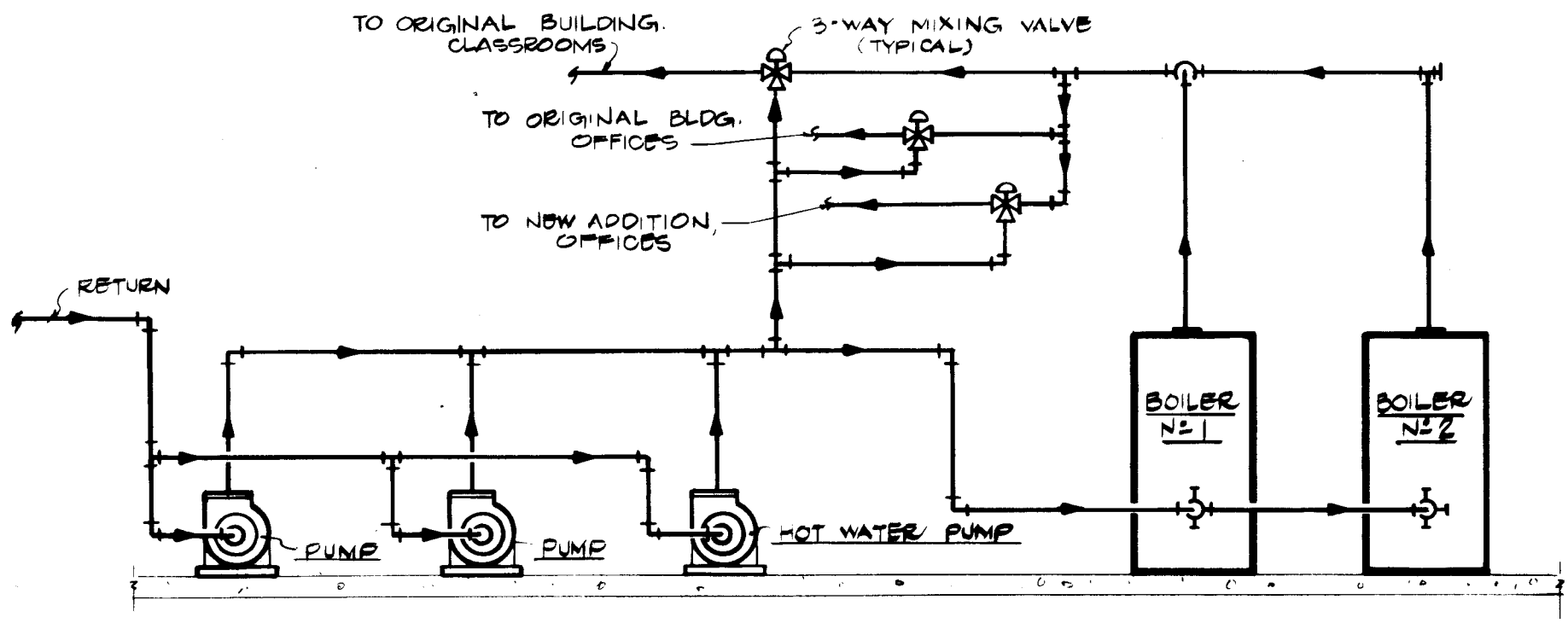


FIGURE 3.8 - HEATING PLANT SCHEMATIC

### 3.6 DOMESTIC HOT WATER

Domestic hot water, supplied to lavatories, miscellaneous sinks and to the kitchen for dishwashing, is supplied by a 4,500-watt electric-fired domestic water heater and a propane fired domestic water heater. Non-recirculated hot water is distributed throughout the building. An independent booster heater (9KW) at the dishwasher raises hot water temperature for sterilization purposes.

#### 4.0 DATA COLLECTION AND SIMULATION

A survey of the existing building and an interview with the building operator were conducted to develop input data for the computer simulation of the school. Previous years' utility bills were collected to use for comparison against the computer output. Modifications to the input program were performed to develop a computer model which behaved similarly to the actual building.

#### 4.1 ACTUAL ENERGY CONSUMPTION

The annual utility bills for the previous two years for fuel oil and electricity were obtained from the school and are listed below:

##### Fuel Energy - Heating & Ventilating

<u>Year</u>	<u>Gals. Oil</u>	<u>Gals./Sq.Ft.</u>	<u>Degree Days</u>	<u>Gals./DD</u>
1973-74	34,751	.70	4,452	7.8
1974-75	33,047	.67	4,594	7.2

##### Electric Energy - Light and Power

<u>Year</u>	<u>KWH</u>	<u>KWH/Sq.Ft.</u>
1973-74	163,740	3.31
1974-75	159,950	3.23

Monthly consumption for 1973/74 and 1974/75 are plotted on Charts 4.1 and 4.2

#### 4.2 BUILDING SURVEY

The observations of a building survey performed to determine the actual operating characteristics of the building are summarized below:

##### Library

The unit ventilators in the library were not connected to the night setback time clock and run continuously during night operation. This was being corrected by the school maintenance department.

##### Typical Classroom Windows

Clearstory windows in each classroom were painted to reduce excessive glare. (See Section 3.0, Figure 3.3)

##### Entrance Infiltration

The main entrance is left open by students creating excessive drafts in the corridors. (See Section 3.0, Figure 3.6)

MONTHLY ELECTRIC USE (KWH)

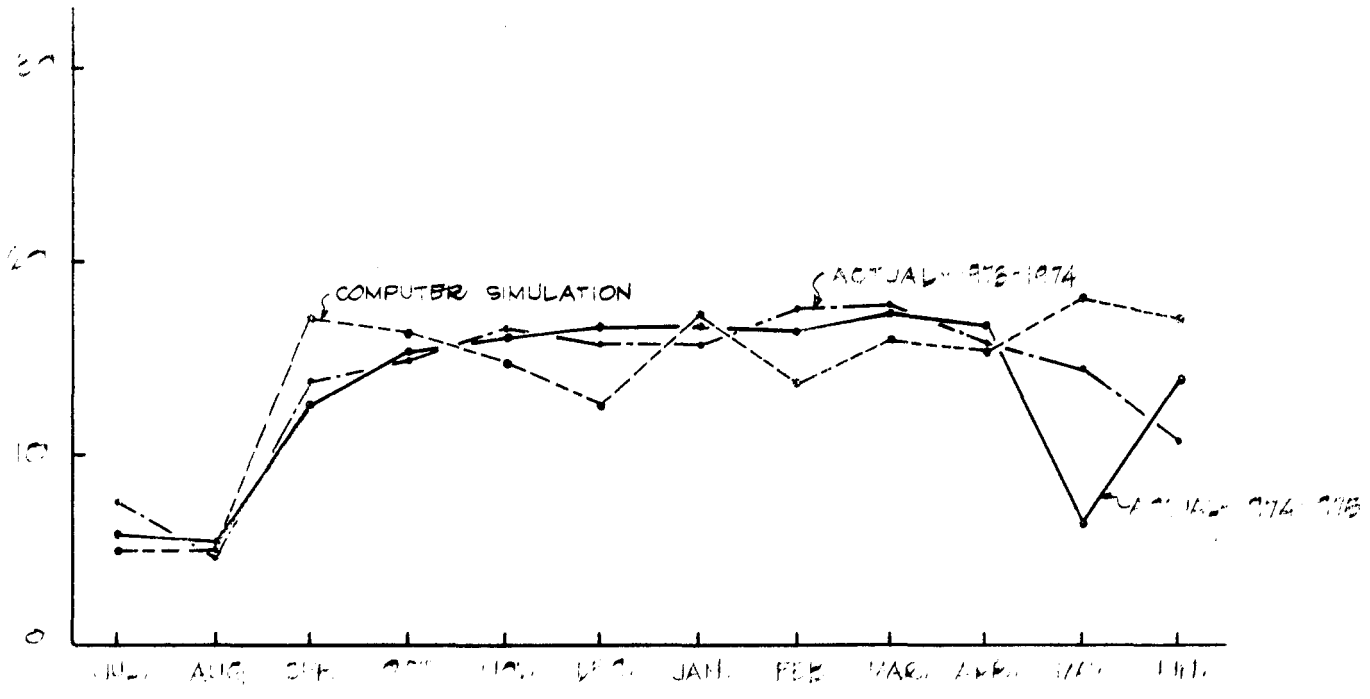


CHART 4.1 - PROFILE OF ELECTRIC USE (KWH)

MONTHLY OIL USE (1000 GALS)

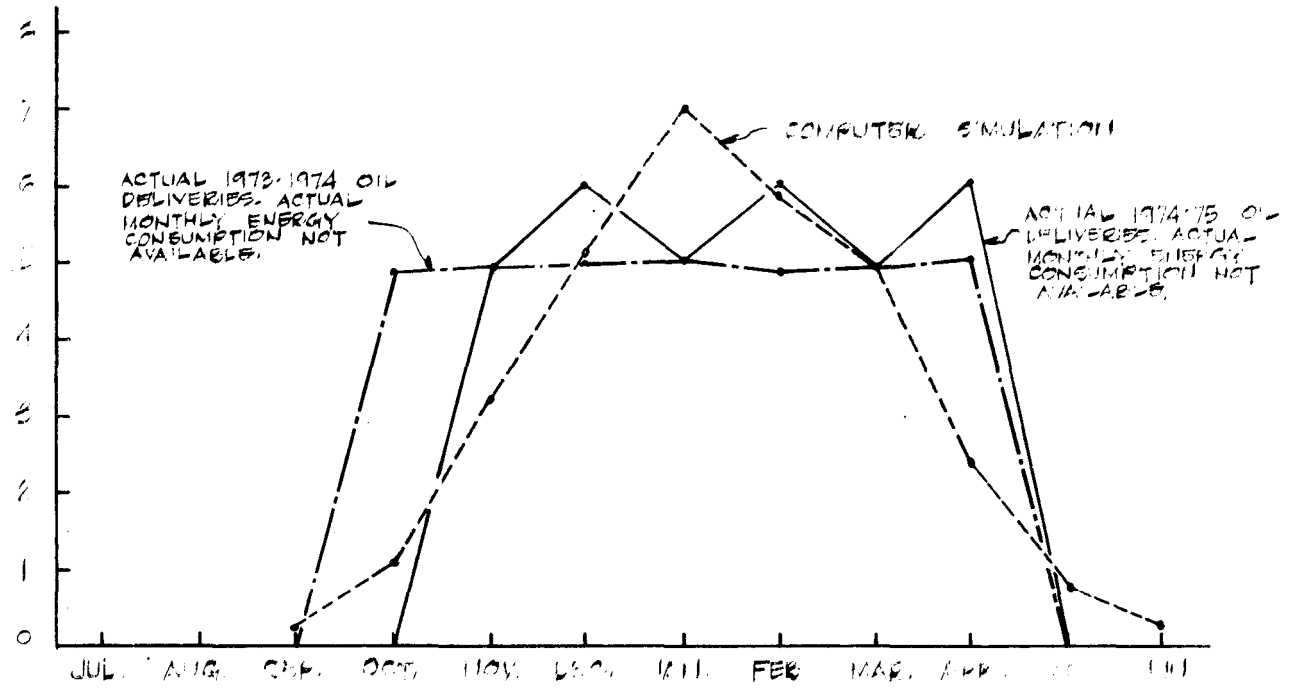


CHART 4.2 - PROFILE OF OIL USAGE (1000 GALS)



### Unit Ventilators

The unit ventilators were operating satisfactorily and were maintaining room temperature of 68 degrees F. during day operation.

### Boiler Plant

The boilers had a history of satisfactory operation but had no provision for low-water cut-off. One pump was operating to provide for the heating needs of the building.

#### 4.3 COMPUTER SIMULATION

The final model which was input into the computer, resulted in a simulated annual heating energy consumption within 9% of actual 1974-75 fuel consumption, and a simulated electric energy consumption within 5% of actual 1974-75 electric consumption. These results are summarized below:

<u>Heating Energy</u>	<u>Gals. Oil</u>	<u>Degree Days</u>	<u>Gals./DD</u>
Computer	31,450	4,774	6.58
1974-75	33,047	4,594	7.19

<u>Electric Energy</u>	<u>KWH</u>
Computer	160,852
1974-75	159,950

Charts 4.1 and 4.2 compare the actual vs. computer monthly energy consumption.

#### 4.4 ENERGY BREAKDOWN

An analysis of the computer simulation revealed the following breakdown of annual heating and electric energy required for this school:

##### Heating Energy

Roof Transmission	16.5%
Infiltrated Air Heating	21.5%
Walls and Glass Transmission	47.0%
Outside Air Heating	15.0%

##### Electric Energy

Lighting	63.0%
Power	31.0%
Air Conditioning	6.0%

## 5.0 DESCRIPTION OF ENERGY CONSERVATION OPPORTUNITIES

The computer simulation which approximated actual energy use was divided into energy consumption components to determine areas of possible energy savings (see Figures 5.1 and 5.2).

Possible energy conservation measures were determined by analyzing the computer simulation results and from a field survey of the building. The items which appeared cost effective are described below and the economics for each item are discussed in Section 6.0.

### 5.1 MECHANICAL

#### Item No. M-1 - Reduce Outside Air Quantities

The present unit ventilator system supplies 500 cubic feet per minute of outside air per classroom. This can be reduced to 175 cubic feet per minute per classroom based on the "School Plant Guide" from the State of Pennsylvania Department of Education. The guide requires 7-1/2 cfm of outdoor air per student. This is equivalent to 175 cfm per classroom.

Item No. M-1 would require a rebalancing of each unit ventilator.

#### Item No. M-2 - Replace Boilers

The existing boilers can be replaced with 3,000 MBH output modular hot water boilers which would increase the seasonal efficiency of the boiler plant from 55% to 70% or greater.

### 5.2 ELECTRICAL

The electrical system does not warrant modification to reduce energy consumption. Classroom lighting has the desired flexibility and appears to be monitored closely by staff members. Exhaust fans have been de-energized wherever possible.

### 5.3 BUILDING

#### Item No. B-1 - Add Second Pane of Plexiglas on Clearstory Glass and Skylights

The clearstory glass above each classroom and the skylights in the corridors can be fitted with a second pane of plexiglas to reduce transmission losses and reduce infiltration.

#### Item No. B-2 - Block Clearstory Glass

The clearstory glass above each corridor can be fitted with a panel to reduce the transmission factor to .30 BTU/Hr. sq. ft. degrees F. which is equivalent to the wall 'U' value.

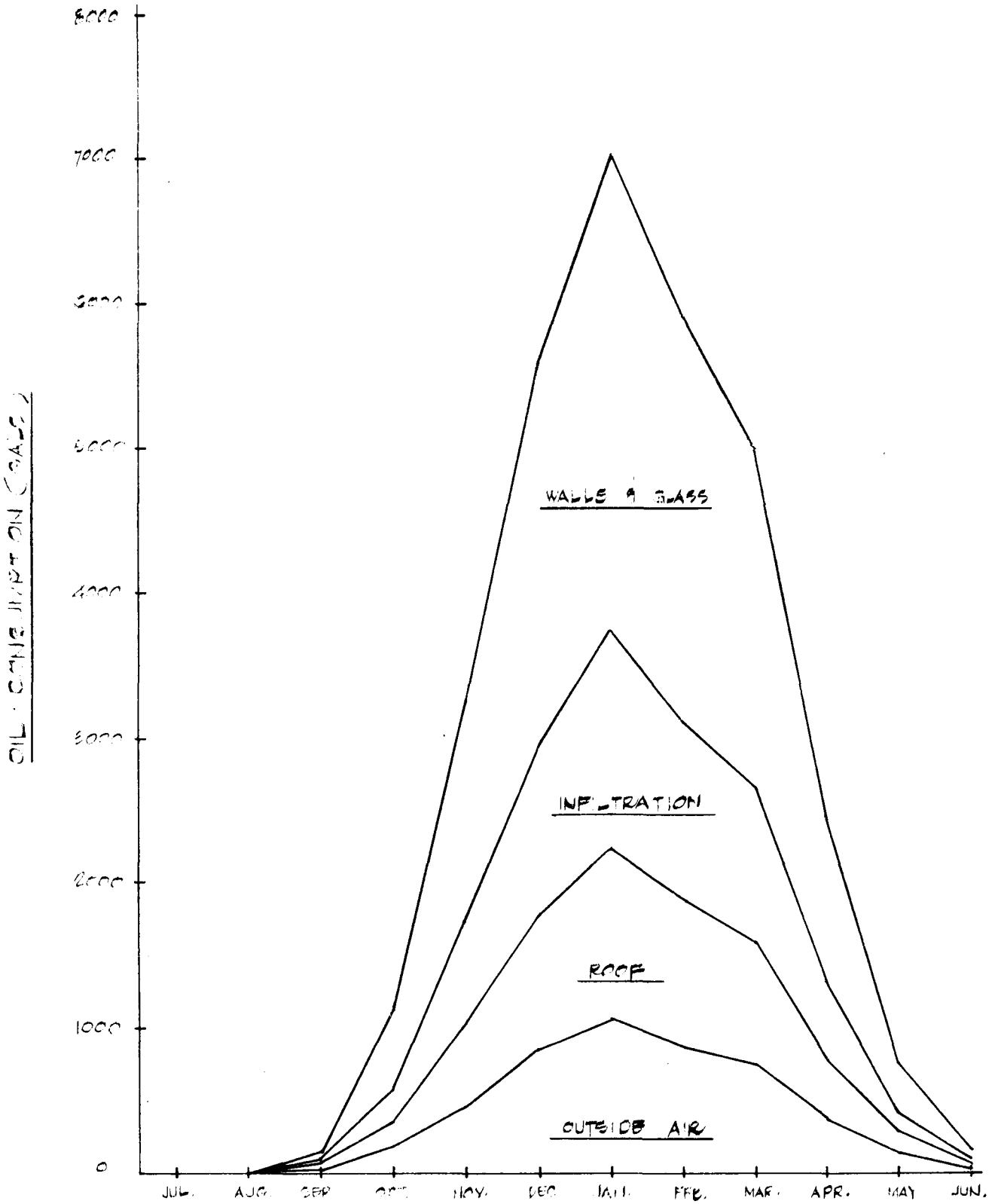


FIGURE 51 - BREAKDOWN OF OIL CONSUMPTION

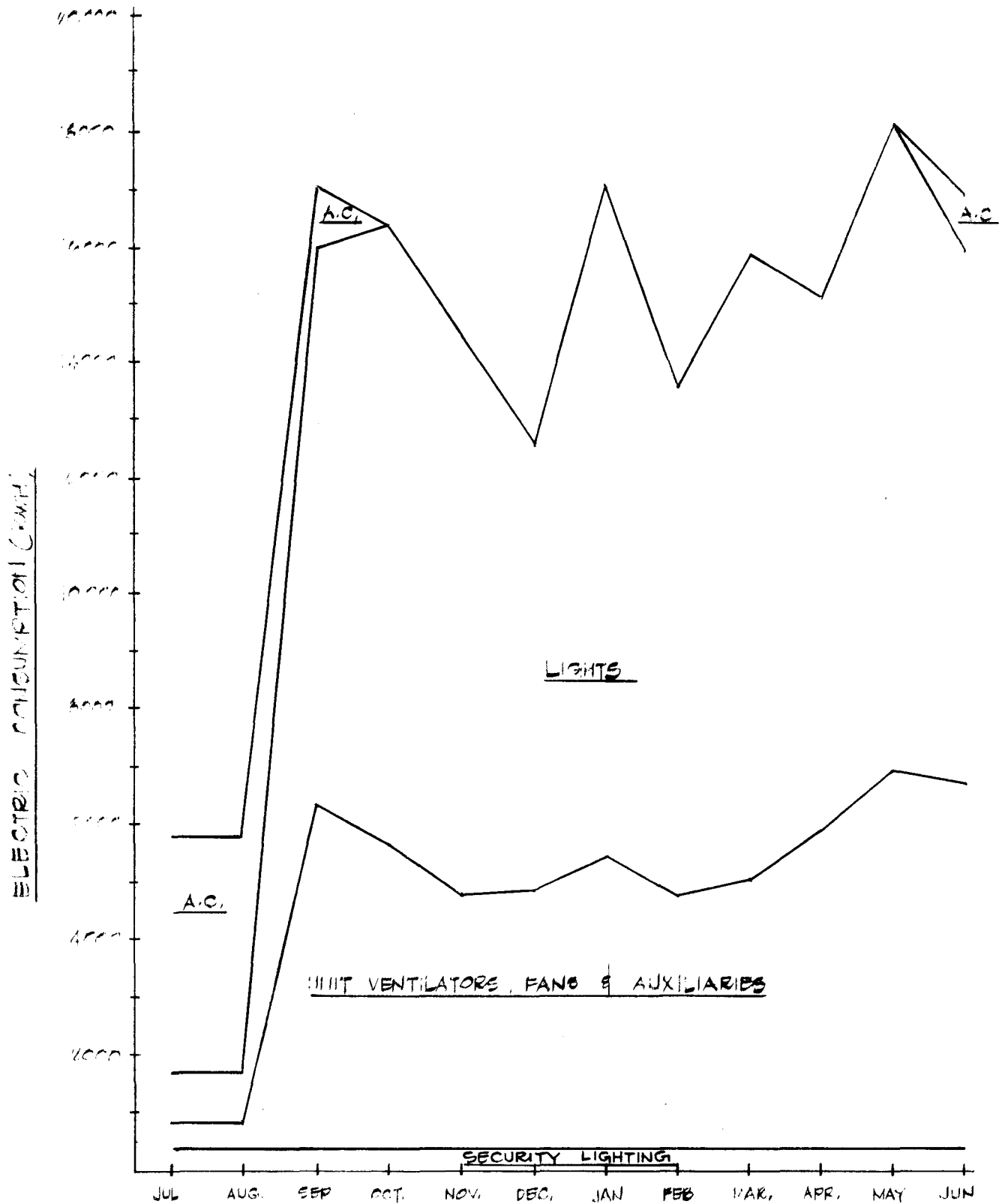


FIGURE B-2 - BREAKDOWN OF ELECTRIC CONSUMPTION

## 6.0 ECONOMIC EVALUATION

An economic analysis of each item described in Section 5.0 was performed to determine the payback period to recover the initial capital expenditure with operating energy savings. The payback period was determined by comparing totalized annual energy savings to the initial capital expenditure plus the totalized annual interest cost. The year in which the total savings equaled the total capital expenditure plus interest is the payback period. The current bond rate for Samuel Everitt Elementary School (6.75%) and the latest energy costs, with an estimated 10% per year escalation were used to determine the totalized energy costs and totalized interest cost. The first cost, annual energy savings and payback period for each item described in Section 5.0, have been summarized in Table 6.1; these values are independent and not additive.

The savings associated with each item have been calculated individually and care should be exercised in evaluating the total savings of combined items. Table 6.2 summarizes the impact of each energy conservation measure assuming that Item M-2 (New Boilers) has been initiated.

TABLE 6.1

ECONOMIC EVALUATIONS

(Annual energy savings are independent and not additive)

<u>Item</u>	<u>First Cost</u>	<u>Annual Energy Savings (Units)</u>	<u>Savings (Cost)*</u>	<u>Payback Period (Years)</u>
M-1 "Reduce Outside Air Quantities"	\$ 1,200	2,130 gals.	\$ 720	2
M-2 "New Boilers"	20,000	7,080 gals.	2,400	11
B-1 "Add Double Pane of Glass to Clearstory Glass and Skylights"	30,000	3,570 gals.	1,200	35
B-2 "Block Clearstory Glass"	25,000	4,700 gals.	1,585	21

\* Present fuel oil cost = \$.337/gal.

Energy savings are not additive. The individual alternatives encompass portions of other alternatives and therefore should be considered independently.

TABLE 6.2

ALTERNATIVE NUMBER	DESCRIPTION	ANNUAL ELECTRICAL CONSUMPTION KW-HRS/\$	ANNUAL ELECTRICAL SAVINGS KW-HRS/\$	ANNUAL OIL CONSUMPTION GALS./\$	ANNUAL OIL SAVINGS GALS./\$	TOTAL ANNUAL UTILITY COST \$	TOTAL ENERGY SAVINGS 1st YEAR \$	ESTIMATED CAPITAL COST OF MODIFICATION	PAYBACK YEARS
ACTUAL BILLING	School Year 1973-1974	163,740/ \$9,333	---	34,751/ \$11,711	---	\$20,879	---	---	---
ACTUAL BILLING	School Year 1974-1975	159,950/ \$9,117	---	33,047/ \$11,137	---	\$20,254	---	---	---
	Calibration Present Operation Simulation	160,852/ \$9,168	---	31,450/ \$10,599	---	\$19,767	---	---	---
M-1	Outside Air Reduction	160,852 \$9,168	---	29,775/ \$10,034	1,675/ \$565	\$19,202	\$ 720	\$ 1,200	2
M-2	New Boilers	160,852/ \$9,168	---	24,370/ \$8,199	7,080/ \$2,400	\$17,367	\$2,400	\$20,000	11
B-1	Double Glaze Clearstory Glass	160,852/ \$9,168	---	28,650/ \$9,655	2,800/ \$944	\$18,823	\$ 944	\$30,000	35+
B-2	Eliminate Clearstory Glass	160,852/ \$9,168	---	27,760/ \$9,355	3,690/ \$1,233	\$18,523	\$1,244	\$25,000	25+

- NOTES:
1. Electrical Costs at \$.057/KWH
  2. Oil Costs at \$.337/gal.
  3. Energy costs and savings are for the first year.
  4. Energy savings are not additive. The individual alternatives encompass parts of other alternatives and therefore should be considered independently.

#### 6.1 REDUCE OUTSIDE AIR QUANTITIES

Item No. M-1 considers rebalancing the unit ventilators to reduce the amount of outside air they supply down to present code requirements. The cost of rebalancing is approximately \$1,200 and results in heating energy savings of \$720 per year. This item has a payback period of 2 years.

#### 6.2 NEW BOILERS

Item No. M-2 looked at replacing the original water tube boilers with 3,000 MBH output modular hot water boilers. The increased seasonal efficiency realized from the new boilers would result in annual savings of \$2,400. At a first cost of \$20,000, this yields an 11 year payback period.

#### 6.3 ADD DOUBLE PANE GLASS

Item No. B-1 considered the installation of a second pane of plexiglas at the clearstory above each classroom. The annual savings of \$1,200 does not justify the initial capital expenditure of \$30,000, which has a 35 year payback period.

#### 6.4 ADD PANEL TO CLEARSTORY GLASS

Item No. B-2 considers blocking the clearstory glass with a panel which would essentially create a surface of similar heat transfer properties to the existing walls. This would incur a first cost of \$25,000 and realize savings of \$1,585 per year which is a 21 year payback period.

## 7.0 RECOMMENDATIONS

We recommend that the following energy conservation measures be implemented in order to reduce energy consumption in Samuel Everitt Elementary School.

1. Reduce the outdoor air quantities for each unit ventilator -- Item No. M-1.
2. Replace the existing boilers with a modular hot water boiler plant -- Item No. M-2.

These recommendations which have a total first cost of \$21,200 would result in a payback period of 7 years at present fuel rates and anticipated escalation.

## 8.0 CONCLUSIONS

The analysis of Samuel Everitt Elementary School revealed a building operation which is energy conscious; space temperatures are maintained at 68 degrees F. during occupied hours and building systems are set back at night to minimize energy consumption. In order to generate any additional energy savings, a capital expenditure is required. This capital expenditure can be moderate (in the case of rebalancing the unit ventilators) or major (for replacing the existing boiler plant with a modular hot water boiler plant).

In developing potential energy conservation measures, the analyzer should be aware of the following factors:

- o Current design "rules and regulations" applicable to the particular school.
- o Potential for energy conservation in the energy generating process.

TABLE 8.1

SUMMARY OF CONCLUSIONS

Samuel Everitt  
 Elementary School  
 K - 5th grade  
 559 students  
 30 staff

1954 Original Building  
 20 C.R. + M.P.R.  
 Walls: 4" F.B. + 8" C.B.  
 Roof: B.U.R. + 3½" Insulrock  
 Glass: S.P.; 45% wall area

Heating System  
 Oil  
 H.W.  
 U.V.  
 4500 degree days

1967 Addition  
 M.R. & Library  
 Walls: see  
 Roof: above  
 Glass: above

Lighting  
 Fluorescent

1958 Addition  
 4 C.R.  
 Walls: see  
 Roof: above  
 Glass: above

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<u>Energy Conservation Item</u>	<u>Initial Capital Cost</u>	<u>Annual Savings</u>
M-1 "Reduce Outside Air Quantities"	\$ 1,200	\$ 720
M-2 "Replace Boilers"	20,000	2,400
B-1 "Add Double Pane Glass"	30,000	1,200
B-2 "Block Glass"	25,000	1,585

APPENDIX A

ENERGY REQUIREMENT ESTIMATE PROGRAM FOR

AASA ENERGY PROGRAM EVERITT ELEMENTARY SCHOOL, LANGHORNE PENN. (Present Building)

MONTHLY AND ANNUAL LOADS

	HEATING MBTU	HEAT HOURS	COOLING TON-HRS	COOL HOURS	HUMIDFCN MBTU	IND PROC MBTU	DIN PROC MBTU	PS ELEC A KWH	PS ELEC P KWH	PS ELEC C KWH	T T PS FL KWH	AUX F HRS
JAN	581504.	744	0.	0	0.	0.	0.	12027.	0.	5117.	17144.	0
FEB	486948.	672	0.	0	0.	0.	0.	9090.	0.	4437.	13127.	0
MAR	395837.	744	0.	0	0.	0.	0.	11087.	0.	4743.	15930.	0
APR	196456.	620	0.	0	0.	0.	0.	9638.	0.	5525.	15163.	0
MAY	23722.	501	0.	0	0.	0.	0.	11557.	0.	4594.	16113.	0
JUN	12256.	189	0.	0	0.	0.	0.	10576.	0.	6354.	16931.	0
JUL	0.	0	0.	0	0.	0.	0.	1220.	0.	527.	1747.	0
AUG	0.	0	0.	0	0.	0.	0.	1220.	0.	527.	1747.	0
SEP	11540.	174	0.	0	0.	0.	0.	11046.	0.	6014.	17606.	0
OCT	88823.	607	0.	0	0.	0.	0.	11087.	0.	5304.	16391.	0
NOV	256905.	664	0.	0	0.	0.	0.	10108.	0.	4369.	14477.	0
DEC	443241.	744	0.	0	0.	0.	0.	8266.	0.	4403.	12671.	0
ANN	*2490974.	5659	0.	0	0.	0.	0.	106929.	0.	53924.	160852.	0

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\*Heating Energy Required

Fuel Oil Consumption = 2,490,974 MBTU

144,000 BTU/gal. x 55% efficiency

= 31,450 gals. @ 4,774

degree days

ENERGY REQUIREMENT ESTIMATE PROGRAM FOR

AASA ENERGY PROGRAM EVERITT ELEMENTARY SCHOOL, LANGHORNE PENN. (Add Double Pane of Glass to Clearstory)

MONTHLY AND ANNUAL LOADS

	HEATING MBTU	HEAT HOURS	COOLING TON-HRS	COOL HOURS	HUMIDIFCN MBTU	IND PROC MBTU	DIP PROC MBTU	FS ELEC A KWH	BS ELEC B KWH	FS ELEC C KWH	T.T BS EL KWH	AUX F HRS
JAN	490392.	744	0.	0	0.	0.	0.	12027.	0.	4760.	16787.	0
FEB	413641.	672	0.	0	0.	0.	0.	9090.	0.	3808.	12898.	0
MAR	354096.	744	0.	0	0.	0.	0.	11087.	0.	5185.	16272.	0
APR	174905.	620	0.	0	0.	0.	0.	9638.	0.	5763.	15401.	0
MAY	55343.	501	0.	0	0.	0.	0.	11557.	0.	6715.	18272.	0
JUN	12290.	189	0.	0	0.	0.	0.	10578.	0.	6409.	16987.	0
JUL	0.	0	0.	0	0.	0.	0.	1220.	0.	527.	1747.	0
AUG	0.	0	0.	0	0.	0.	0.	1220.	0.	527.	1747.	0
SEP	11540.	174	0.	0	0.	0.	0.	11048.	0.	5967.	17015.	0
OCT	79082.	607	0.	0	0.	0.	0.	11087.	0.	5440.	16527.	0
NOV	229783.	664	0.	0	0.	0.	0.	10108.	0.	4335.	14443.	0
DEC	394147.	744	0.	0	0.	0.	0.	8268.	0.	3774.	12042.	0
ANN	* 2215222.	5659	0.	0	0.	0.	0.	106929.	0.	53210.	160138.	0

\*Heating Energy Required

$$\text{Fuel Oil Consumption} = \frac{2,215,222 \text{ MBTU}}{144,000 \text{ BTU/gal.} \times 55\% \text{ efficiency}} = 27,970 \text{ gals.} @ 4,774 \text{ degree days}$$

A-2

APPENDIX B

APPENDIX B

BACK-UP CALCULATIONS

I. BUILDING CONSTRUCTION (ASHRAE Handbook of Fundamentals, pages 357-374)

<u>Roof</u>	<u>'R' Value</u>
Outside Surface	.17
Built-up Roofing	.33
3-1/2" Insulrock	8.33
Inside Air Film	.61
	<hr/>
	9.44

$$U = 1/R = .10 \text{ BTU/Hr. sq.ft. degree F.}$$

<u>Walls</u>	<u>'R' Value</u>
Outside Surface	.17
4" Face Brick	.80
Air Space	.97
4" Concrete Block	.31
Inside Air Film	.68
	<hr/>
	2.93

$$U = 1/R = .30 \text{ BTU/Hr. sq.ft. degree F.}$$

II. BUILDING INFILTRATION (ASHRAE Handbook of Fundamentals, pages 337-338)

Typical Classroom = (1) Door, 7'-0" x 2'-6"  
(7) Operable casement windows (3'-6" x 1'-6")  
(4) Operable casement windows at Clearstory (3'-6" x 1'-6")

Assume one air change per classroom.

Assume 3/4 air change for building.

$$\text{Outside Air} = \frac{3/4 \times 493,140 \text{ cubic feet}}{60 \text{ minutes per hour}} = 6,000 \text{ cfm}$$

III. DESIGN LOADS (Based on 68 degrees F. indoors, 0 degrees F. outdoors)

Transmission

1,300 MBTU/Hr. --- Walls, roof, windows

Outside Air

1,230 MBTU/Hr. --- 16,750 cfm ventilation air

Infiltration

440 MBTU/Hr. --- 6,000 cfm outside air

IV. WEATHER DATA

1973-74 Degree Days --- 4,452 (U. S. Weather Bureau)

1974-75 Degree Days --- 4,594 (U. S. Weather Bureau)

Computer Degree Days -- 4,774 (New York City Weather Tape)