GUIDELINES FOR ENERGY EFFICIENT SCHOOLS

JAMES D. McCLURE, P.E.
JAMES M. ESTES, P.E.
Consulting Engineers
Estes, McClure & Assoc. Inc.
Tyler, Texas

KIRBY N. BICKNELL
MIKE C. ESTES
Consulting Engineers
Estes, McClure & Assoc. Inc.
Tyler, Texas

ABSTRACT

Operational experience of several schools designed with energy efficiency as a design criteria is discussed in this paper. Actual monthly energy usage and cost are provided. Annual energy cost performance ($\$/ft^2$-yr) and energy performance (BTU/FT^2-yr) of these example case study schools with flexible mechanical and electrical systems are compared to published design performance guidelines and similar schools constructed without energy efficiency as a design criteria. The authors have conducted energy studies of more than 400 schools which serve as a comparative data base range of performance.

Of the schools compared, those with the lowest operating cost and energy usage employed flexible HVAC systems which inherently provided for control of electrical demand. The resulting electrical demand profile of most of these case study schools were relatively constant throughout the year which is uncommon to most schools. The design approach employed to achieve lower operating costs and inherent demand control is a hybrid HVAC system with a designed mixture or balance between electric and natural gas energy sources.

The summary of this paper will compare operating cost performance, energy performance, HVAC system type of the case study schools, eight schools with water source heat pumps, and other data base schools with various other types of HVAC systems. Design guidelines for energy efficient schools are presented.

INTRODUCTION

Texas Public Schools collectively spend approximately $260 million annually for energy to operate facilities. A wide variation of performance (cost and energy) has been observed during on-site observations and energy studies of more than 400 Texas Public School buildings throughout Texas (See Figure 1). For example, the observed energy performance of elementary schools has ranged from 26,000 Btu/ft^2-yr (site) to 188,000 Btu/ft^2-yr (site) (1). Operating costs performance for these elementary schools ranged from $\$0.40/ft^2$-yr to $\$1.51/ft^2$-yr. Most schools in Texas use more energy than established guidelines for performance (see Figure 2).

The opportunity for energy savings in Texas is a resource (energy and dollars), which if taped on a statewide massive basis, can save school districts and taxpayers millions of dollars. Twenty-one million dollars annually can be saved simply by efficient operation of Texas schools during the summer time. This is approximately

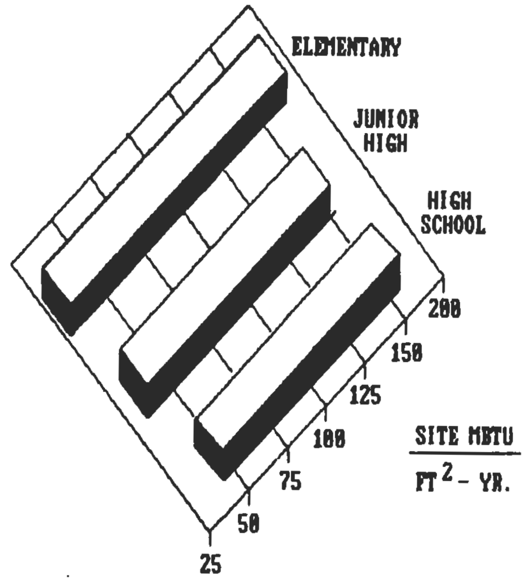

Figure 1: Existing Texas Schools Exhibit Wide Range of Energy Performance

equivalent to annual salaries for 1,159 teachers (See Figure 3). Even more savings are achievable during the regular school year. To achieve massive energy and dollars savings, engineers, architects, contractors, school administrators, school maintenance and operating personnel, utilities, and state governments must function as a team to establish and implement energy efficiency policies and guidelines.

The purpose of this paper is to share our experience in conducting energy studies of more than 400 school buildings located throughout Texas, to provide guidelines for energy efficient schools based on these studies, and experience in designing mechanical and electrical system for schools, and

ENERGY BUDGETS (3) IN SITE BTUS PER SQUARE FOOT PER YEAR

CITY	ELEMENTARY	SECONDARY
AMARILLO	37,000	47,000
BROWNSVILLE	34,000	47,000
DALLAS	36,000	48,000
EL PASO	35,000	46,000
HOUSTON	34,000	46,000
LUBBOCK	38,000	47,000
SAN ANTONIO	35,000	47,000

Figure 2: Energy Budget Guidelines

Proceedings of the Fifth Symposium on Improving Building Systems in Hot and Humid Climates, Houston, TX, September 12-14, 1988

SUMMER ENERGY SHUTDOWN

- 5992 SCHOOLS(2) • 357,240,000 SQ. FT. (EST.)
- $0.73/SQ. FT.-YR. AVERAGE ENERGY COST
- $260 MILLION TOTAL TEXAS ENERGY COST FOR SCHOOLS
- 6% AVERAGE ANNUAL SAVINGS FOR EFFICIENT SUMMER OPERATIONS
- $21 MILLION ANNUAL SUMMER SAVINGS POTENTIAL
- EQUIVALENT TO APPROXIMATELY 1159 TEACHERS ANNUAL SALARY

Figure 3: Dollar Savings Potential in Texas Schools During Summer

to provide conclusions/recommendations for achieving energy cost savings on a large scale basis. The experience and data in this paper are for school buildings in hot, and hot and humid climates.

SCHOOL DATA/OBSERVATIONS

Nineteen schools were selected for this paper which represent typical HVAC systems found in Texas Public Schools. Five types of HVAC systems are among the nineteen schools. These nineteen school buildings were selected, because they represent relatively new construction, have one electric meter and one gas meter and are all located within the same region of Texas (see Figure 4.)

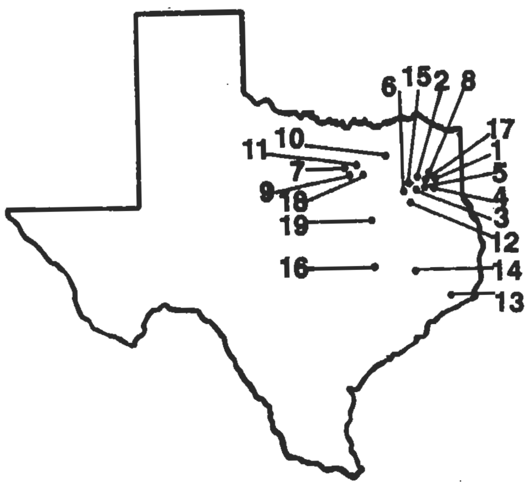

Figure 4: Location of Sample Schools

The variation of the nineteen schools operating cost performance is shown in Figure 5. Operating cost performance is expressed in dollars per square foot for a one year period. The schools are grouped in the figure by type of air-conditioning system as follows: schools number 1-6 flexible system, schools number 7 - 8 multizone systems, schools number 9 - 12 water source heat pumps, schools number 13 - 17 central chilled water systems, schools number 18 - 19 central variable air volume systems. The schools are served by several different utilities. All of the operating cost data shown in Figure 5 and other Figures in this paper represent the same electric rates (Texas Utilities) in order to establish a common baseline for comparison. Texas Utilities Rate MS is illustrated to the left of the data line and where demand readings were available for some of the schools, Texas Utilities Rate G is illustrated to the right of the MS rate lines. Rate G includes charges for demand (KW) where rate MS does not have demand. The cost for natural gas used in the illustrations is $4.00 per thousand cubic feet (MCF) which is representative of most schools current cost.

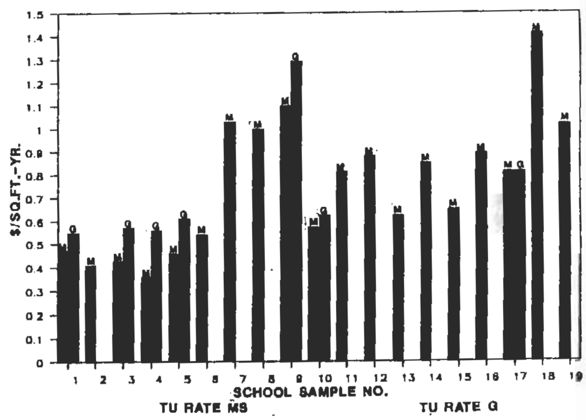

Figure 5: School Energy Cost Performance

Figure 6, Average Operating Cost, is also listed in units of dollars per square foot for a one year period. The graph utilizes the same nineteen schools and is an average of each type of system from the values in Figure 5.

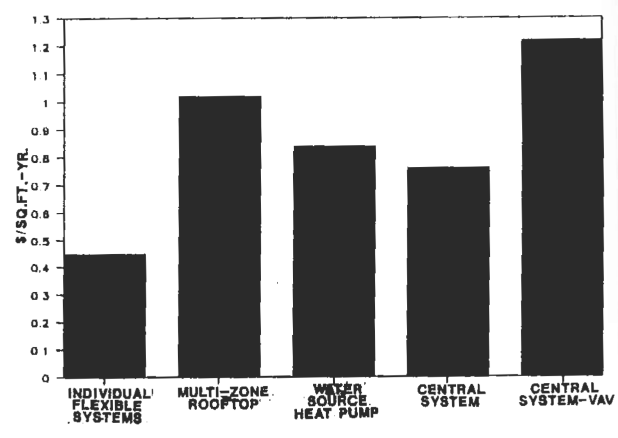

Figure 6: Average Operating Cost of Sample Schools By Type of Air-Conditioning System

Most of the schools in the sample group, as in common with our 400 plus school data base, operate with energy usage greater than the published energy budgets. Figure 7 compares the elementary schools and Figure 8 compares the secondary schools. The units are in site Btu's per

Proceedings of the Fifth Symposium on Improving Building Systems in Hot and Humid Climates, Houston, TX, September 12-14, 1988

square foot for a one year period. The Btu's are calculated by multiplying the total kilowatt-hour (KWH) usage by 3,413 btu per KWH, and multiplying total mcf of natural gas consumption by 1,030,000 Btu per mcf. These two values are for a one year period and are added together then divided by the total square footage of the facility.

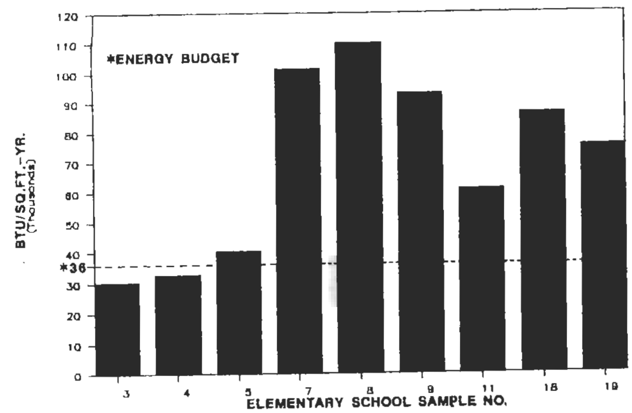

Figure 7: Individual Elementary Schools Individual Energy Performance Compared to Published Energy Budget

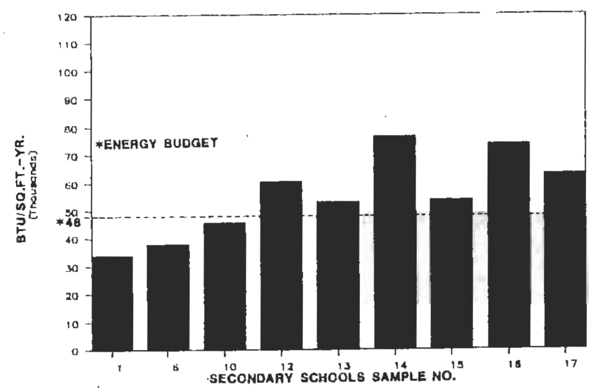

Figure 8: Individual Secondary Schools Energy Performance Compared to Published Energy Budget

The monthly school utility data for the nineteen schools are provided in Appendix Figures 10 through 28. This data shows the actual energy consumption and monthly cost using Texas Utilities Rate MS and G, and $4.00/mcf natural gas.

A utility summary of fifty Texas schools (5,024,633 square feet of area) of all types and ages was compiled to estimate average performance. The following are data from these analyses which are based on actual costs using the specific utility of the individual schools.

AVG. ENERGY PERFORMANCE 61,431 BTU/FT^2-YR (SITE)

AVG. COST PERFORMANCE $0.73/FT^2-YR.

AVG. ELECTRIC COST $0.0648/KW-HR

AVG. NATURAL GAS COST $4.45/MCF

A survey of schools having Thermal Storage type air conditioning system was prepared and mailed to schools known to have this type of system. Only one school responded and no operating cost or usage data was provided.

ELECTRIC UTILITY RATE CONSIDERATIONS

A thorough understanding and evaluation of the specific utility company's actual rates available are required for energy efficient designs and operations. There are factors in most electric rates that effect the cost of operation but not necessarily the Btu performance of the building. A major factor is the billing demand (KW) part of the electric bill. The demand (KW) is the highest load (usually a 15 minute average interval) during the billing month. Most utilities also have some type of ratchet clause for billing demand which often utilizes the highest load for the year and prescribes a minimum demand charge which must be paid regardless of lower actual demand readings (such as in the summer). Therefore, it is very important to reduce the peak demand. Most schools do not operate in the summer time or have very restricted summer operations and set peak demand values in the September billing month. This one value can cost the school in other months beside September due to the ratchet clause. Figure 9 illustrates the demand profiles of two schools. One line of the graph shows the actual KW readings and another line shows the KW billed. Where the two lines separate in the figure, the ratchet clause has taken effect. This type of billing can drastically effect the overall annual billing.

TEXAS UTILITIES RATES USED IN FIGURE 5.

Texas Utilities Rate MS and Rate G were used to establish a baseline for comparing the sample schools in Figure 5. The MS rate is a flat rate which charges the customer a $15 per month customer charge and approximately $0.048 per KWH for the billing months of November through April and approximately $0.065 per KWH for the billing months of May through October. This flat rate does include a fuel factor and cogeneration power cost factor.

Rate G of Texas Utilities is currently not utilized by most public schools (due to higher costs for most facilities) but is included in Figure 4 to model a rate with demand billing. Rate G has a customer charge of $10 per month, $4.05 per KW of demand in excess of 10 kw and the following three tiers for the energy charge:

$0.045 per KWH first 2500 KWH

$0.025 per KWH next 3500 KWH
(Add 170 kwh per kw of demand in excess of 10 kw.)

$0.0067 per KWH all additional KWH

Proceedings of the Fifth Symposium on Improving Building Systems in Hot and Humid Climates, Houston, TX, September 12-14, 1988

Also a fuel factor and cogeneration power cost factor of approximately $0.023 per kwh for all kwh is added to the billing.

OBSERVATIONS OF SCHOOL DATA BANK

Our data base shows that schools, regardless of location in Texas, having flexible mechanical and electrical systems consistently achieve better energy performance and lower operating cost. These flexible systems characteristically are those decentralized systems which permit operation of energy systems when an area or zone is occupied, and permit turning-off systems when an area is unoccupied. They include flexibility in lighting switching. Schools have significant characteristics unlike other facilities such as buildings for office, retail, manufacturing, medical, and other functions. These differences (e.g. hours of operations, multiple-use, function, part year usage, holidays, schedule, loading, etc.) have significant impact on optimum designs and construction approaches. The sample schools and data shown in Figure 5, and summarized in Figure 6 are typical of our findings throughout the State of Texas in our larger data base. This data shows that air-conditioning system type significantly effects the operating cost of schools. Of the nineteen schools, only one other than those with individual flexible systems has energy performance that met the published energy budget/performance guidelines.

AIR-CONDITIONING SYSTEM CHARACTERISTICS OF SCHOOLS WITH LOWEST OPERATING COST

The schools having the lowest operating cost in our extensive data base and in the nineteen school comparative study are those with individual flexible systems. A more accurate description is "Individual Flexible Hybrid Systems". These systems include individual split-systems or individual packaged roof-top air conditioning units for each classroom. The individual units are electric cooling direct expansion. The heating source for these units within the data base are electric strip, heat pumps, or natural gas fired furnaces. Each classroom has its own thermostat. In areas with higher fresh air loads(e.g. gymnasiums, auditoriums, dressing areas) and higher heating loads, larger air-handlers with electric direct expansion cooling are provided. Space heating for these units is provided by hot water coils and a small packaged energy efficient natural gas boiler. Economizer cycles are provided for these units where appropriate. The flexible hybrid approach of using a mixture of electric heating (electric strip or heat pumps) and natural gas heating also minimizes first cost and results in a more constant demand level each month of the year (See Figure 9, School No. 1). Note that the peak demand (Figure 9) occurred in September which is typical for most schools. Eighty percent of the peak demand for this school in September and October is very near the demand for the remainder of the year. Better demand control using the energy management control system in these few months would have provided lower operating costs and reduced the ratchet effect cost of the minimum billing. This design (Figure 9, School No. 1) accomplished by the authors had individual heat pumps (air-cooled) on exterior zone classrooms, individual direct-expansion units (air-cooled) with electric strip heating (on interior zone classrooms), electric direct expansion cooling (with economizer cycle) air-handlers with hot water heating coils (small natural gas fired boiler), energy efficient lighting (75 ft. candles in classroom) and switching, energy management control system, special control functions for the air-conditioning system (e.g. hot water reset, lock out of electric strip heaters for heat pump units, etc.), short-circuit integral make-up supply air kitchen hood (non-tempered supply air), and other architectural and siting features. The kitchen, gymnasiums, shops, and dressing areas were heated and cooled.

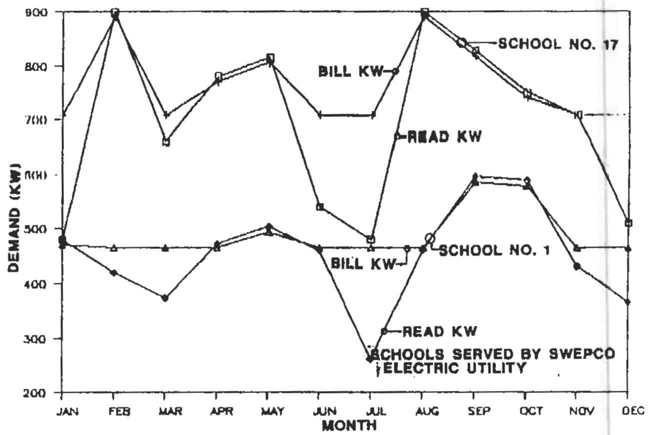

Figure 9: Comparison Of Demand Profiles and Effect Of Ratchet Clause in Rates

Rooftop multizone systems, water source heat pump systems, central chilled water systems, and central chilled water system of the variable air-volume type resulted in higher operating cost and higher energy usage than the individual flexible hybrid type system (See Figures 5 and 6). Individual central chiller units may have more efficient ratings than the individual direct expansion air-cooled units but the overall system components (e.g. pumps, cooling tower fans etc.), schedules of buildings use, and function makes the larger central systems or multi-zone units more costly to operate. We have conducted energy studies of eight Texas schools with water source heat pumps. Operating cost of these schools varied from \$.73 to \$0.94/ft^2-yr as compared to the individual flexible hybrid systems which operated from \$.40 to .50/ft^2-yr. Most of the water source heat pump applications did not have a mixture of exterior and interior zones. A proper mixture would be conducive to good performance. Many of these schools reported numerous water leaks in the plastic piping systems. Regardless of the type of air-conditioning system installed, flexibility is recommended. For example, the office area should have a separate direct-expansion unit for summer use to prevent operating a large chiller just for the office personnel.

Proceedings of the Fifth Symposium on Improving Building Systems in Hot and Humid Climates, Houston, TX, September 12-14, 1988

Reliability, maintainability, and equipment life are considerations to be made for school design. Many schools have been observed to have insufficient maintenance staff and capabilities because of budgets and availability of personnel. The more simple flexible systems are easier to maintain. In general, the controls for central systems are not operating in an optimum manner after a few years. When more complicated central systems are provided, the school should be advised of needed maintenance skills and budgets. Some schools have been observed to pay as much as $10,000 per year per chiller for routine chiller maintenance agreements. The life cycle of equipment and equipment life experience is the subject of another report being prepared by the authors. Data gathered by the authors, published data, and data from one large equipment manufacturer shows that the individual direct expansion units have a life of 15 plus years. In one school we visited, the compressors of individual units were 24 years old with no replacements.

For school buildings located in hot and humid climates, payback analysis and experience shows that low first cost heating systems are practical. School classrooms, especially those of more modern design with relatively small glass area, have a very minimum heating load. The space heating is provided largely by internal heat gain (students and lights). For these reasons, using current electric rates, the individual flexible systems can economically and efficiently use electric strip heating on interior zones and heat pumps on exterior zones. The authors recently conducted extensive computer analyses of a twenty-four classroom arrangement located in central Texas. The typical exterior classroom heating requirement was 4,140,000 Btu/yr. (approximately $60 per year for electric resistance heating) for this simulation. Numerous load analyses of various schools during our design work shows this fact.

DATA NEEDED

Energy efficient schools have been designed, constructed, and operated using current technology and off-the-shelf equipment. New technologies are being implemented by a few schools. These technologies include thermal storage, and double effect efficient natural gas absorption air-conditioning systems. Raw unadjusted data (first cost, operating cost, energy usage) is needed from these type schools for comparisons.

The authors recommend that the utility regulating agencies and utilities review the energy usage and usage profiles of schools. Most electric utilities have indicated that their rate structures in the future will be demand (KW) based with the greater part of the cost to the user derived from demand. There are many old schools in Texas which during the next 30 years will require major renovations or replacements, and some regions are currently constructing and planning new schools. Schools need the agencies and utilities to make long term commitments for basic rate structures in order to plan efficient and lower operating cost schools.

Testing and evaluations of several schools kitchens are recommended to accurately define the effects of kitchen design and energy source for cooking (gas or electric). The energy source for kitchens and operating techniques may be significantly effecting the total billed demand (KW).

SCHOOL ENERGY EFFICIENCY POLICY

There has been much discussion about national and state energy policies. The authors recommended that states develop School Energy Efficiency Policies. Where funding of schools is derived from state resources, it would be a motivation for cost savings in schools if their funding formula included factors for overall energy efficiency of the district.

ACKNOWLEDGMENTS

The large data base for the schools was obtained during the authors design work and energy audit work. Most of the energy audit work was conducted under contract to the Governors Office of Budget and Planning (State of Texas) - Energy Resource Center for Texas Schools and the Public Utility Commission of Texas - Energy Resource Center for Texas Schools. Dr. Mel Roberts was the state's program officer.

References

1. McClure, James D., James M., Building Energy Efficient Schools, Second Annual Symposium Improving Building Energy Efficiency In Hot and Humid Climates, September 24-25, 1985.

2. Texas Education Agency, 1987-88 School Directory, October 1987.

3. McClure, James D., Estes, James M., Building For Energy Efficiency, "the Not-In-The-Red-Schoolhouse", Public Utility Commission of Texas, 1985, p. 48.

Appendix

Figures 10 through 28

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	480	470	103,800	5,015.25	6,636.18	208.7
FEB	420	465	90,900	4,393.83	6,215.03	177.2
MAR	374	465	74,700	3,613.45	5,541.70	99.6
APR	472	465	95,400	4,610.61	6,349.45	74.6
MAY	504	494	112,500	7,335.60	7,067.93	77.2
JUN	460	465	57,000	3,724.10	4,689.05	49.0
JUL	262	465	52,200	3,411.76	4,457.83	1.0
AUG	462	465	87,900	5,734.83	6,125.41	3.2
SEP	596	586	135,900	8,858.28	8,425.75	46.8
OCT	588	578	120,000	7,823.64	7,893.50	76.2
NOV	432	465	94,800	4,581.71	6,331.53	117.9
DEC	366	465	92,100	4,451.64	6,250.88	174.4
TOTAL			1,117,200	63,554.71	75,984.25	1,105.8

DATA PERIOD: 1986-87
SYSTEM: FLEXIBLE

SIZE: 145,933 SQ.FT.
TYPE: SECONDARY

Figure 10: School No. 1 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	142,026	6,856.68	0.00	0.0
FEB	0	0	126,107	6,089.83	0.00	0.0
MAR	0	0	70,953	3,432.95	0.00	0.0
APR	0	0	56,790	2,750.69	0.00	0.0
MAY	0	0	56,165	3,669.77	0.00	0.0
JUN	0	0	29,666	1,945.43	0.00	0.0
JUL	0	0	33,519	2,196.15	0.00	0.0
AUG	0	0	49,503	3,236.26	0.00	0.0
SEP	0	0	89,347	5,828.99	0.00	0.0
OCT	0	0	68,449	4,469.11	0.00	0.0
NOV	0	0	71,167	3,443.26	0.00	0.0
DEC	0	0	118,445	5,720.73	0.00	0.0
TOTAL			912,137	49,639.83	0.00	0.0

DATA PERIOD: 1985-86 SIZE: 121,210 SQ.FT.
SYSTEM: FLEXIBLE TYPE: SECONDARY

Figure 11: School No. 2 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	336	264	47,360	2,296.43	3,410.63	27.4
FEB	336	264	52,800	2,558.48	3,637.55	33.1
MAR	336	264	35,520	1,726.07	2,840.27	30.2
APR	240	230	28,320	1,379.23	2,355.73	31.4
MAY	240	230	31,680	2,076.48	2,517.59	31.7
JUN	240	230	24,960	1,639.20	2,193.87	21.8
JUL	240	230	28,800	1,889.07	2,378.85	12.6
AUG	240	230	8,640	577.22	1,407.71	12.5
SEP	240	230	46,720	3,055.16	3,212.45	19.2
OCT	224	214	46,240	3,023.93	3,083.54	30.3
NOV	224	214	31,680	1,541.09	2,452.79	31.1
DEC	336	264	57,280	2,774.29	3,771.37	32.8
TOTAL			440,000	24,536.66	33,262.34	314.1

DATA PERIOD: 1985-86 SIZE: 60,312 SQ.FT.
SYSTEM: FLEXIBLE TYPE: ELEMENTARY

Figure 12: School No. 3 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	315	259	24,600	1,200.03	2,293.98	75.9
FEB	309	257	23,700	1,156.68	2,242.53	206.4
MAR	165	180	19,500	954.35	1,728.35	51.8
APR	135	180	17,400	853.19	1,627.19	46.8
MAY	135	180	13,200	873.95	1,424.87	20.8
JUN	120	180	9,000	600.65	1,222.55	13.4
JUL	111	180	6,600	444.48	1,106.94	11.4
AUG	240	230	28,200	1,850.03	2,349.95	12.4
SEP	228	218	33,000	2,162.38	2,532.58	15.5
OCT	195	185	23,400	1,537.68	1,936.47	40.6
NOV	309	257	24,600	1,200.03	2,285.88	43.0
DEC	300	255	32,400	1,575.77	2,653.52	103.1
TOTAL			255,600	14,409.22	23,404.81	641.1

DATA PERIOD: 1985-86 SIZE: 46,763 SQ.FT.
SYSTEM: FLEXIBLE TYPE: ELEMENTARY

Figure 13: School No. 4 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	245	235	47,160	2,286.79	3,261.40	250.4
FEB	227	217	42,480	2,061.35	2,995.45	210.8
MAR	212	202	33,120	1,610.46	2,473.56	150.1
APR	238	228	41,400	2,009.32	2,977.72	93.5
MAY	266	256	38,520	2,521.57	2,952.39	25.4
JUN	76	207	11,520	764.63	1,453.29	16.9
JUL	101	207	14,400	952.04	1,592.03	4.5
AUG	274	264	38,520	2,521.57	2,984.79	5.3
SEP	277	267	48,240	3,154.07	3,465.17	11.2
OCT	277	267	37,080	2,427.87	2,927.57	25.4
NOV	238	228	38,160	1,853.24	2,821.64	30.1
DEC	238	228	41,040	1,991.98	2,960.38	112.8
TOTAL			431,640	24,154.89	32,865.37	936.4

DATA PERIOD: 1987 SIZE: 60,300 SQ.FT.
SYSTEM: FLEXIBLE TYPE: ELEMENTARY

Figure 14: School No. 5 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	125,100	6,041.32	0.00	184.9
FEB	0	0	118,980	5,746.50	0.00	181.4
MAR	0	0	114,030	5,508.05	0.00	144.4
APR	0	0	93,690	4,528.23	0.00	101.7
MAY	0	0	132,930	8,665.02	0.00	84.7
JUN	0	0	146,520	9,549.35	0.00	22.4
JUL	0	0	68,130	4,448.36	0.00	12.0
AUG	0	0	104,310	6,802.66	0.00	14.4
SEP	0	0	146,430	9,543.49	0.00	42.3
OCT	0	0	129,150	8,419.05	0.00	63.0
NOV	0	0	112,680	5,443.02	0.00	74.1
DEC	0	0	116,910	5,646.79	0.00	135.6
TOTAL			1,408,860	80,341.85	0.00	1,060.9

DATA PERIOD: 1987 SIZE: 155,763 SQ.FT.
SYSTEM: FLEXIBLE TYPE: SECONDARY

Figure 15: School No. 6 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	45,900	2,226.09	0.00	495.4
FEB	0	0	46,800	2,269.45	0.00	299.6
MAR	0	0	45,000	2,182.74	0.00	226.1
APR	0	0	43,200	2,096.03	0.00	235.7
MAY	0	0	70,200	4,583.05	0.00	65.0
JUN	0	0	70,200	4,583.05	0.00	36.5
JUL	0	0	29,700	1,947.64	0.00	28.9
AUG	0	0	13,500	893.47	0.00	32.4
SEP	0	0	38,700	2,533.29	0.00	29.2
OCT	0	0	71,100	4,641.62	0.00	59.5
NOV	0	0	60,300	2,919.77	0.00	153.8
DEC	0	0	48,600	2,356.16	0.00	349.5
TOTAL			583,200	33,232.37	0.00	2,011.6

DATA PERIOD: 1986-87 SIZE: 40,000 SQ.FT.
SYSTEM: MULTIZONE TYPE: ELEMENTARY

Figure 16: School No. 7 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	46,320	2,246.33	0.00	727.0
FEB	0	0	36,000	1,749.19	0.00	470.0
MAR	0	0	42,160	2,045.93	0.00	323.0
APR	0	0	49,760	2,412.04	0.00	109.0
MAY	0	0	32,640	2,138.95	0.00	43.0
JUN	0	0	20,800	1,368.50	0.00	0.0
JUL	0	0	6,560	441.87	0.00	0.0
AUG	0	0	19,440	1,280.00	0.00	7.0
SEP	0	0	92,080	6,006.83	0.00	12.0
OCT	0	0	59,680	3,898.50	0.00	27.0
NOV	0	0	48,960	2,373.50	0.00	310.0
DEC	0	0	49,200	2,385.06	0.00	351.0
TOTAL			503,600	28,346.70	0.00	2,379.0

DATA PERIOD: 1984-85 SIZE: 37,900 SQ.FT.
SYSTEM: MULTIZONE TYPE: ELEMENTARY

Figure 17: School No. 8 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	360	432	96,000	4,639.51	6,131.06	656.2
FEB	420	432	105,000	5,073.06	6,399.91	371.1
MAR	390	432	97,500	4,711.77	6,175.87	277.2
APR	450	440	99,000	4,784.03	6,277.97	23.0
MAY	450	440	112,500	7,335.60	6,681.24	18.8
JUN	420	432	51,000	3,333.67	4,266.37	1.6
JUL	510	500	22,500	1,479.12	3,168.87	0.0
AUG	540	530	67,500	4,407.36	5,458.11	7.2
SEP	555	545	142,500	9,287.76	8,329.31	16.8
OCT	540	530	121,500	7,921.25	7,594.58	26.1
NOV	465	455	96,000	4,639.51	6,295.77	108.5
DEC	345	432	78,000	3,772.42	5,603.02	216.1
TOTAL			1,089,000	61,385.06	72,382.07	1,722.6

DATA PERIOD: 1986 SIZE: 58,983 SQ.FT.
SYSTEM: WATER SOURCE HEAT PUMP TYPE: ELEMENTARY

Figure 18: School No. 9 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	852	871	207,900	10,029.96	12,617.42	889.3
FEB	767	871	152,800	7,375.68	10,979.98	689.0
MAR	767	871	157,100	7,582.82	11,099.92	348.5
APR	854	871	290,300	13,999.33	15,078.87	125.2
MAY	926	916	124,800	8,135.99	9,781.67	106.2
JUN	759	871	117,200	7,641.44	9,233.31	60.1
JUL	893	883	109,300	7,127.37	8,901.35	31.0
AUG	912	902	244,200	15,905.58	13,923.76	30.0
SEP	1104	1094	367,700	23,941.97	18,987.87	86.1
OCT	832	871	190,600	12,417.72	12,100.63	112.2
NOV	783	871	199,600	9,630.13	12,369.48	425.6
DEC	792	871	172,400	8,319.85	11,556.96	882.5
TOTAL			2,333,900	132,107.85	46,631.23	3,785.7

DATA PERIOD: 1986-87 SIZE: 260,000 SQ.FT.
SYSTEM: WATER SOURCE HEAT PUMP TYPE: SECONDARY

Figure 19: School No. 10 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	64,800	3,136.55	0.00	345.0
FEB	0	0	65,250	3,158.22	0.00	77.0
MAR	0	0	55,350	2,681.32	0.00	57.0
APR	0	0	54,450	2,637.97	0.00	20.0
MAY	0	0	66,600	4,348.80	0.00	6.0
JUN	0	0	53,550	3,499.61	0.00	11.0
JUL	0	0	29,700	1,947.64	0.00	7.0
AUG	0	0	62,550	4,085.25	0.00	8.0
SEP	0	0	79,200	5,168.70	0.00	12.0
OCT	0	0	61,200	3,997.41	0.00	21.0
NOV	0	0	39,755	1,930.08	0.00	49.0
DEC	0	0	50,400	2,442.87	0.00	198.0
TOTAL			682,805	39,034.40	0.00	811.0

DATA PERIOD: 1984-85 SIZE: 52,000 SQ.FT.
SYSTEM: WATER SOURCE HEAT PUMP TYPE: ELEMENTARY

Figure 20: School NO. 11 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	101,700	4,914.09	0.00	446.0
FEB	0	0	135,000	6,518.22	0.00	144.0
MAR	0	0	136,800	6,604.93	0.00	106.0
APR	0	0	136,800	6,604.93	0.00	53.0
MAY	0	0	135,000	8,799.72	0.00	60.0
JUN	0	0	152,100	9,912.45	0.00	57.0
JUL	0	0	162,000	10,556.66	0.00	0.0
AUG	0	0	130,500	8,506.90	0.00	4.0
SEP	0	0	189,900	12,372.17	0.00	43.0
OCT	0	0	168,300	10,966.62	0.00	67.0
NOV	0	0	121,500	5,867.90	0.00	110.0
DEC	0	0	132,109	6,378.95	0.00	146.0
TOTAL			1,701,709	98,003.55	0.00	1,236.0

DATA PERIOD: 1984-85 SIZE: 116,844 SQ.FT.
SYSTEM: WATER SOURCE HEAT PUMP TYPE: SECONDARY

Figure 21: School No. 12 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	76,608	3,705.36	0.00	526.0
FEB	0	0	78,336	3,788.60	0.00	303.0
MAR	0	0	64,320	3,113.42	0.00	366.0
APR	0	0	73,344	3,548.13	0.00	219.0
MAY	0	0	96,768	6,311.89	0.00	78.0
JUN	0	0	59,520	3,888.09	0.00	8.0
JUL	0	0	62,976	4,112.97	0.00	23.0
AUG	0	0	74,688	4,875.10	0.00	7.0
SEP	0	0	99,264	6,474.31	0.00	4.0
OCT	0	0	98,496	6,424.33	0.00	110.0
NOV	0	0	89,280	4,315.80	0.00	96.0
DEC	0	0	88,512	4,278.80	0.00	315.0
TOTAL			962,112	54,836.79	0.00	2,055.0

DATA PERIOD: 1986-87 SIZE: 101,679 SQ.FT.
SYSTEM: CENTRAL CHILLED WATER TYPE: SECONDARY

Figure 22: School No. 13 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	58,560	2,835.95	0.00	414.7
FEB	0	0	57,600	2,789.71	0.00	610.7
MAR	0	0	102,720	4,963.23	0.00	229.8
APR	0	0	65,280	3,159.67	0.00	144.1
MAY	0	0	66,240	4,325.37	0.00	88.2
JUN	0	0	75,840	4,950.06	0.00	56.5
JUL	0	0	68,160	4,450.31	0.00	23.4
AUG	0	0	74,880	4,887.59	0.00	11.6
SEP	0	0	102,720	6,699.20	0.00	47.0
OCT	0	0	93,120	6,074.50	0.00	94.8
NOV	0	0	98,880	4,778.25	0.00	176.7
DEC	0	0	105,600	5,101.96	0.00	554.4
TOTAL			969,600	55,015.80	0.00	2,451.9

DATA PERIOD: 1985 SIZE: 76,282 SQ.FT.
SYSTEM: CENTRAL CHILLED WATER TYPE: SECONDARY

Figure 23: School No. 14 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	93,844	4,535.65	0.00	274.0
FEB	0	0	121,038	5,845.64	0.00	504.0
MAR	0	0	79,100	3,825.41	0.00	279.0
APR	0	0	79,596	3,849.30	0.00	133.0
MAY	0	0	79,660	5,198.64	0.00	59.0
JUN	0	0	64,276	4,197.57	0.00	5.0
JUL	0	0	48,784	3,189.47	0.00	5.0
AUG	0	0	54,936	3,589.80	0.00	5.0
SEP	0	0	117,060	7,632.33	0.00	34.0
OCT	0	0	66,580	4,347.49	0.00	49.0
NOV	0	0	58,850	2,849.92	0.00	78.0
DEC	0	0	84,088	4,065.69	0.00	198.0
TOTAL			947,812	53,126.90	0.00	1,623.0

DATA PERIOD: 1984 SIZE: 91,470 SQ.FT.
SYSTEM: CENTRAL CHILLED WATER TYPE: SECONDARY

Figure 24: School No. 15 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	108,000	5,217.58	0.00	461.1
FEB	0	0	129,600	6,258.09	0.00	962.2
MAR	0	0	139,200	6,720.54	0.00	375.0
APR	0	0	151,200	7,298.61	0.00	386.8
MAY	0	0	178,800	11,649.87	0.00	126.7
JUN	0	0	127,200	8,292.16	0.00	81.0
JUL	0	0	111,000	7,237.99	0.00	49.3
AUG	0	0	126,000	8,214.07	0.00	12.1
SEP	0	0	168,600	10,986.14	0.00	22.8
OCT	0	0	189,000	12,313.61	0.00	75.7
NOV	0	0	189,700	9,153.23	0.00	217.7
DEC	0	0	111,000	5,362.09	0.00	509.2
TOTAL			1,729,300	98,703.98	0.00	3,279.6

DATA PERIOD: 1985 SIZE: 126,000 SQ.FT.
SYSTEM: CENTRAL CHILLED WATER TYPE: SECONDARY

Figure 25: School No. 16 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	480	708	157,800	7,616.54	9,953.59	562.4
FEB	900	890	195,000	9,408.54	12,368.13	1,439.8
MAR	660	708	180,900	8,729.31	10,643.63	150.7
APR	780	770	219,300	10,579.12	12,234.70	103.7
MAY	816	806	221,100	14,402.42	12,546.27	53.4
JUN	540	708	150,000	9,775.80	9,720.59	23.5
JUL	480	708	176,400	11,493.70	10,509.21	21.3
AUG	900	890	294,000	19,146.17	15,325.46	23.9
SEP	828	818	239,400	15,593.24	13,178.85	47.5
OCT	750	740	231,000	15,046.63	12,369.37	68.1
NOV	708	708	202,200	9,755.38	11,279.91	194.1
DEC	510	708	175,800	8,483.64	10,491.29	948.8
TOTAL			2,442,900	140,030.49	140,620.99	3,637.2

DATA PERIOD: 1985 SIZE: 191,650 SQ.FT.
SYSTEM: CENTRAL CHILLED WATER TYPE: SECONDARY

Figure 26: School No. 17 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	113,559	5,485.36	0.00	0.0
FEB	0	0		0.00	0.00	0.0
MAR	0	0	162,995	7,866.80	0.00	0.0
APR	0	0	74,211	3,589.89	0.00	0.0
MAY	0	0	80,401	5,246.85	0.00	0.0
JUN	0	0	75,137	4,904.31	0.00	0.0
JUL	0	0	28,209	1,850.62	0.00	0.0
AUG	0	0	40,027	2,619.64	0.00	0.0
SEP	0	0	118,347	7,716.08	0.00	0.0
OCT	0	0	158,403	10,322.60	0.00	0.0
NOV	0	0	167,232	8,070.90	0.00	0.0
DEC	0	0	122,157	5,899.55	0.00	0.0
TOTAL			1,140,678	63,572.60	0.00	0.0

DATA PERIOD: 1985-86 SIZE: 45,000 SQ.FT.
SYSTEM: CENTRAL VARIABLE AIR VOLUME TYPE: ELEMENTARY

Figure 27: School No. 18 Monthly Utility Data

MONTH	READ KW	BILL KW	KWH	$ (MS)	$ (G)	MCF
JAN	0	0	60,000	2,905.32	0.00	99.0
FEB	0	0	51,600	2,500.68	0.00	85.5
MAR	0	0	49,800	2,413.97	0.00	54.5
APR	0	0	50,400	2,442.87	0.00	66.6
MAY	0	0	30,900	2,025.72	0.00	39.6
JUN	0	0	20,100	1,322.95	0.00	13.4
JUL	0	0	43,200	2,826.11	0.00	8.3
AUG	0	0	54,900	3,587.45	0.00	7.9
SEP	0	0	60,000	3,919.32	0.00	27.8
OCT	0	0	51,000	3,333.67	0.00	35.8
NOV	0	0	61,800	2,992.03	0.00	38.4
DEC	0	0	66,900	3,237.71	0.00	92.3
TOTAL			600,600	33,507.79	0.00	569.1

DATA PERIOD: 1987 SIZE: 35,000 SQ.FT.
SYSTEM: CENTRAL VARIABLE AIR VOLUME TYPE: ELEMENTARY

Figure 28: School No. 19 Monthly Utility Data