# PERFORMANCE OF ENERGY MANAGEMENT CONTROL SYSTEMS (EMCS) IN SELECTED TEXAS LoanSTAR BUILDINGS



A Report by

Michelle M. Schmode

Submitted to the Mechanical Engineering Department of Texas A&M University in partial fulfillment of the requirement for the degree of Master of Science



August 1995



Major Subject: Mechanical Engineering

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## *Abstract*

This report describes an investigation of energy use at various LoanSTAR sites. The effects of installing Energy Management Control Systems (EMCS) on electricity consumption was studied at four LoanSTAR sites: Stroman High School, Victoria High school, Sims Elementary School, and Zachry Engineering Center. In the course of this study, LoanSTAR monitoring data was used to analyze the changes in energy consumption based only on EMCS retrofits. The results will show that the installation of EMCS was successful in reducing energy consumption and/or changing the hourly energy consumption pattern.

## *Table of Contents*

## *Introduction*

### Background

"Energy retrofits can cut use and costs." "Direct digital control system saves over 40 percent in energy costs." "University sheds HVAC system for state-of-the-art energy management control." "Vision and technology revolutionize Bryant College." "Control system offers remedy for hospital's energy use ailments." These are some of the headlines found in *Buildings* and *Mechanical Engineering* magazines. Many facility managers are moving toward Energy Management Control Systems (EMCS) or Direct Digital Control systems (DDC) in an effort to reduce energy costs. These efforts have claimed to be successful; however, few reports detail exacly how and/or why the savings occurred.

The following briefly describes the results reported in the above mentioned articles. In general, energy conservation retrofits can reduce the energy use of buildings by 10 to 30 percent, with paybacks typically in the 2- to 4- year range.[1] The Valley Building, an 8-year-old office tower in Renton, Washington achieved a 40 percent savings in energy costs within six months of installing a DDCS.[2] The C.W. Post campus of Long Island University, Brookville, New York, does not report specific monetary savings, rather they report significant maintenance staff labor savings and energy savings due to their EMCS keeping their target setpoints more effectively.[3] Bryant College in Smithville, Rhode Island has achieved energy savings of about $34,000 per year since they installed a DDCS.[4] Craven Regional Medical Center in New Bern, North Carolina, saves an estimated $65,000 in electric costs per year since the installation and proper utilization of an EMCS.[5]

The objective of this report is to determine how successful Energy Management Control Systems have been in reducing energy consumption.

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[1] Claridge, D.E., et al 1994. "Energy retrofits can cut use and costs." *Mechanical Engineering*, August, pp. 64-67.
[2] Editor, 1991. *Buildings*, December, p.16.
[3] Editor, 1992. *Buildings*, September, p. 34.
[4] Mumford, S., 1994. *Buildings*, February, pp. 38-41.
[5] Editor, 1993. *Buildings*, May, p 38.

## The LoanSTAR Program[6]

In 1988, the Texas Governor's Energy Management Center (GEMC)[7] received approval from the U.S. Department of Energy to establish a $98.6 million statewide retrofit demonstration revolving loan program, the LoanSTAR (Loans to Save Taxes and Resources) program. The LoanSTAR program uses a revolving loan financing mechanism to fund energy-conservation retrofits in state and local government buildings and public schools. Potential retrofit projects are identified by energy audits conducted by engineering teams under contract to the Texas SECO. Each proposed retrofit competes for funds on the basis of the estimated payback period, the ability to repay the loan through energy savings, an engineering assessment of the viability of the retrofit, and the feasibility of monitoring the project effectively.

The projects funded by the LoanSTAR program primarily include retrofits to lighting, HVAC systems, building shell, electric motors, and EMCS.

The LoanSTAR Monitoring and Analysis Program (MAP) was designed to serve the differing needs of the many participants in the LoanSTAR revolving loan program. The energy monitoring program's first objective is to determine whether retrofits save as much as estimated in audits. The second objective of the MAP is to reduce energy costs of a building by using the monitored data to evaluate its energy-using characteristics, and to diagnose opportunities for improved operations. The final major objective of energy monitoring is the establishment of an end-use database for institutional and commercial buildings in Texas.

The LoanSTAR MAP is not set up to collect monitoring data based on individual retrofits. This would be too costly; therefore, tracking the performance of groups of retrofits was chosen over tracking of specific retrofits. This report evaluates the LoanSTAR monitored data in order to isolate the changes in energy usage based only on EMCS retrofits.

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[6] Turner, W.D., 1990. "Overview of the Texas LoanSTAR Monitoring Program," *Proceedingts of the Seventh Annual Symposium on Improving Building Systems in Hot and Humid C limates*, College Station, Texas: Texas A&M University. October 9-10, pp. 28-34

[7] The GEMC is now called the Texas State Energy Conservation Office (SECO)

## *Methodology*

### Site Selection

The LoanSTAR program currently monitors 90 sites. Sites studied in this report were chosen based on the following:

a) EMCS retrofit was completed,
b) whole building and limited sub-metered hourly data were collected (utilizing one-to four-channel data acquisition systems or data loggers), and
c) ease of separating EMCS retrofit data from whole building data.

The final list of sites studied is:

a) Stroman High School (SHS), Victoria Independent School District,
b) Victoria High School (VHS), Victoria Independent School District,
c) Sims Elementary School (SIM), Fort Worth Independent School District, and
d) Zachry Engineering Center (ZEC), Texas A&M University, College Station.

A data summary notebook is prepared by the Monitoring and Analysis Task of the Texas LoanSTAR program. It provides various plots, giving an historical look at all of the data that has been collected for all of the LoanSTAR sites. Zachry Engineering Center (ZEC) data summary plots are included as a comparison to the methodology used in this report. The charts and table prepared for the other sites were not prepared for ZEC.

### Data Reduction

The raw data were obtained from a database maintained by the Energy Systems Lab (ESL) at Texas A&M University under the LoanSTAR MAP. A number of data loggers were installed to collect specific consumption data for each site. The location of the data loggers is indicated on monitoring diagrams, which are included for each site in the Appendices.

The data was extracted from the database using an ESL program called "Getdatc." It is a simple program that expedites the retrieval of data from the LoanSTAR database. It allows the user to obtain columns of logger channel data and to perform calculations on the data quickly and easily. Getdatc outputs the data with timestamps and, when necessary, bad data marks (-99).[8] Data was retrieved for a

[8] Getdatc is copyrighted public domain software developed by the Energy Systems Laboratory, Texas A&M University, Mechanical Engineering Department, College Station, TX 77843-3123

period defined as the report period, which varies from site to site. In all cases, the report period commenced on the monitoring start date for the study site . The report periods for each site are as follows:

| | |
|---|---|
| Stroman High School | 6/5/91 through 6/4/94 |
| Victoria High School | 6/5/91 through 6/4/94 |
| Sims Elementary School | 10/1/91 through 5/31/95 |
| Zachry Engineering Center | 5/31/89 through 10/29/94 |

To facilitate subsequent data manipulation, the report periods were subdivided into annual blocks of data. For this report, the "whole building" data was extracted. A list showing the information contained in the whole building data set is shown in Figure 1. The output was in the form of an ASCII file, which could be edited and imported into other software for further manipulation.

In order to separate the effects of other retrofits, a list of channels and equations associated with the whole building calculations was reviewed. This list is included in each site Appendix. As an example, the listing for Stroman High School is shown in Figure 1.

**Figure 1: Getdatc "listwb" output for Stroman High School**

| Cp | Name | Expression |
|---|---|---|
| 1 | wbele | ch0323 |
| 2 | wbcool | ch0324/1000 |
| 3 | wbheat | ch0326*0.00103 |
| 4 | oadrybulb | ch0827 |
| 5 | oarh | dp2rh(ch0827,ch0828) |
| 6 | chiller | ch0325 |
| 7 | windspeed | ch0829 |

| channel ID | Description |
|---|---|
| 0323 | Whole Bldg (kWh/h) (126,8) |
| 0324 | ChW (kBtu) (126,9) |
| 0325 | Chiller (kWh/h) (126,10) |
| 0326 | Gas Meter (cuft) (126,11) |
| 0827 | VCT Dry Bulb (Victoria) (850,8) |
| 0828 | VCT Dew Point (Victoria) (850,9) |
| 0829 | VCT Wind Speed (Victoria) (850,10) |

The monitoring diagram in Appendix A, Tab A-3 shows the location of the channel where the consumption is measured. Electricity consumption is being examined in this report. This includes all channels which are kilowatt-hour per hour (kWh/h) (channels 0323 and 0325 in Figure 1).

Stroman High School had three retrofits: install an EMCS, replace absorption chiller with electric chiller, and rewire hallway wiring. The effects of the new electric chiller consumption can be eliminated by subtracting chiller consumption (channel 0325, measured at the chiller) from whole building electricity consumption (channel 0323, measured before the electrial main panel). Similar reasoning is used for the data reductions of the other study sites.

Once the data were extracted from the LoanSTAR database, the data file was reduced to two columns of data: decimal date and consumption. This was done using a MS DOS routine called "gawk-f." A *.awk file was created using a text editor. It contains a statement which specifies the column numbers corresponding to the columns of data to be extracted from the getdatc *.acs file. The output file is in ascii format. This process was repeated for all consumption categories to be studied.

Next, the output data file was transformed from columnar format to tabular format using an ESL program called "ColRow3D." [9] It is a columnar data manipulation program which processes hourly energy consumption data to produce a "new" file containing a spread sheet compatible data matrix. ColRow3D transforms each day's worth of data into one row in the matrix. For example, a leap year's worth of hourly data (8764 lines) will be compressed down to just 366 lines of data. The ColRow3D output file was opened in Microsoft Excel for further manipulation.

After each ColRow3D file was opened in MS Excel, they were combined into one .xls worksheet, covering the entire report period. At this point, the data was in consecutive date order. Columns were inserted at the beginning of the worksheet to input sort parameters, which are:

| | |
|---|---|
| 1/0 | weekday/weekend |
| A/B | pre-/post-retrofit |
| S/NS | semester/non-semester |

Ones and zeros were input into the '1/0' column, where a "1" indicates a weekday and a "0" indicates a weekend. A's and B's were input into the "A/B" column, where an "A" indicates a pre- retrofit date and a "B" indicates a post- retrofit date. S's and NS's were input in the "S/NS" column, where an "S" indicates a semester day and a "NS" indicates a non-semester day.

[9] ColRow3D is copyrighted public domain software developed by the Energy Systems Laboratory, Texas A&M University Mechanical Engineering Department, College Station, TX 77843-3123

A school district schedule was obtained for each site which indicates holidays, breaks, and days when school was not in session. For this report, all holidays, semester breaks and summers were considered non-semester days. The summers were categorized as non-semester for the two independent school districts, even though they held summer school sessions. Consumption during the summer, even with summer school in session, was significantly less than normal school year consumption. In order to avoid falsely reducing the daily average data, the summers were categorized as non-semester.

For cells which contained a "-99" (missing data) or a "0", the content of the cell was replaced with a blank cell. This allows mathematical functions to be used on the data without including erroneous data or zeroes, which would result in bad results (either too large or too small of totals or averages).

The hourly data for each date was summed to obtain total daily data. The total daily consumption was plotted against the day of year for each energy consumption category. This is the timeline plot shown in each site Appendix, Figure 3. The total monthly consumption was then calculated. The data were presented in tabular format in each site Appendix, Table 2. These calclulations were performed for each consumption category.

Next, the "other electric" data was sorted on pre-/post-retrofit (A/B) and semester/non-semester (S/NS). The daily totals were summed for post-retrofit, semester (B, S) and post-retrofit, non-semester (B, NS). The sort category totals are represented as a percentage of whole building electricity consumption in a pie chart, shown in each site Appendix, Figure 4. The sort totals were then multiplied by the appropriate cost of energy ($/unit of energy) to obtain the total cost of energy. The data were presented in tabular form in each site Appendix, Table 1

Average hourly consumption (other electric) was calculated by sorting the data based on (1) semester/non-semester (S/NS), (2) weekday/weekend (1/0), and (3) pre-/post-retrofit (A/B). This yielded eight sort categories:

| | |
|---|---|
| S-1-A | semester/weekday/pre-retrofit |
| S-1-B | semester/weekday/post-retrofit |
| S-0-A | semester/weekend/pre-retrofit |
| S-0-B | semester/weekend/post-retrofit |
| NS-1-A | non-semester/weekday/pre-retrofit |
| NS-1-B | non-semester/weekday/post-retrofit |
| NS-0-A | non-semester/weekend/pre-retrofit |
| NS-0-B | non-semester/weekend/post-retrofit |

The hourly consumption (other electric) was averaged for each sort category. This represents the average hourly consumption for each hour of the day. It was calculated for only those hours when the equipment was actually on. The average hourly consumption was plotted against hour of day to obtain daily profiles, which are shown in each site Appendix, Figure 5.

## *Summary of Results*

All sites showed both reductions and increases in "other" electricity consumption. The term "other" is defined differently for each site. For Stroman and Victoria High Schools, it is whole building electricity minus chiller electricity consumption. For Sims Elementary Schools, it is whole building electricity minus lighting electricity consumption. For Zachry Engineering Center, whole building electric was analyzed instead of "other" electricity consumption.

Table 2 summarizes the difference in other electric consumption for all study sites except Zachry Engineering Center. Stroman and Victoria High Schools both showed reductions in other electricity consumption for each category except semester/weekend. Sims Elementary School showed reductions in other electricity consumption for each category except semester/weekday. Possible explanations for these increases are discussed in each site Appendix.

Table 3 summarizes the whole building electricity consumption for all sites, for the pre-retrofit period and the most recent year of post-retrofit period. The square footage of each site is also shown in this table. Table 4 summarizes the whole building electricity consumption for all sites, normalized on a square footage basis. From the data shown in both of these tables, one can see that Stroman and Victoria High Schools are relatively low energy use sites, while Sims Elementary School and Zachry Engineering Center are relatively high energy use sites

**Table 2:** ***Summary of Differences in "Other Electric" Consumption***

| | # days in sort category | Average Daily Consumption kWh/day | Difference in Average Daily Consumption kWh/day | % Difference in Average Daily Consumption |
|---|---|---|---|---|
| **STROMAN HIGH SCHOOL** | | | | |
| Semester | | | | |
| weekday-pre | 91 | 5,210 | | |
| weekday-post | 394 | 4,525 | -685 | -13.15% |
| weekend-pre | 35 | 2,206 | | |
| weekend-post | 149 | 2,395 | 189 | 8.57% |
| Non-semester | | | | |
| weekday-pre | 79 | 3,557 | | |
| weekday-post | 241 | 3,225 | -332 | -9.33% |
| weekend-pre | 33 | 2,060 | | |
| weekend-post | 92 | 1,930 | -130 | -6.31% |
| **VICTORIA HIGH SCHOOL** | | | | |
| Semester | | | | |
| weekday-pre | 91 | 7,877 | | |
| weekday-post | 394 | 6,889 | -988 | -12.54% |
| weekend-pre | 35 | 3,674 | | |
| weekend-post | 149 | 4,245 | 571 | 15.54% |
| Non-semester | | | | |
| weekday-pre | 79 | 6,159 | | |
| weekday-post | 241 | 5,182 | -977 | -15.86% |
| weekend-pre | 33 | 4,180 | | |
| weekend-post | 92 | 3,017 | -1,163 | -27.82% |
| **SIMS ELEMENTARY SCHOOL** | | | | |
| Semester | | | | |
| weekday-pre | 514 | 1,453 | | |
| weekday-post | 229 | 1,617 | 164 | 11.29% |
| weekend-pre | 192 | 861 | | |
| weekend-post | 88 | 444 | -417 | -48.41% |
| Non-semester | | | | |
| weekday-pre | 148 | 1-517 | | |
| weekday-post | 66 | 1,479 | -38 | -2.48% |
| weekend-pre | 72 | 1,235 | | |
| weekend-post | 543 | -692 | -692 | -56.03% |

**Table 3:** *Summary of Whole Building Electricity Consumption, pre- and post-retrofit periods*

| Site | Pre-Retrofit Period kWh | Post-Retrofit Period kWh | Conditioned Area sq. ft. |
|---|---|---|---|
| Stroman High School | 1,207,697[10] | 1,184,318[11] | 210,414 |
| Victoria High School | 1,499,242[12] | 1,845,529[13] | 257,014 |
| Sims Elementary School | 1,816,566[14] | 660,673[15] | 62,400 |
| Zachry Engineering Center | 14,727,147[16] | 8,555,071[17] | 324,400 |

**Table 4:** *Summary of Whole Building Electricity Consumption per square foot, post-retrofit*

| Site | annual consumption per square foot kWh/SF/year[18] | annual cost per square foot $/SF/year |
|---|---|---|
| Stroman High School | 5.63 | .01570 |
| Victoria High School | 7.18 | .02002 |
| Sims Elementary School | 10.59 | .07138 |
| Zachry Engineering Center | 26.37 | .07352 |

Figures 2 through 5 show the average hourly profiles for each study site. The changes in other electricity consumption are easier to see in these figures. Detailed discussions of these plots are contained in the site Appendices. The nighttime consumption (5:00 p.m. to 6:00 a.m.) dropped for all sites. The increases in consumption seen in Table 2 can be seen in the average hourly profiles as well. More interesting to note is the change in the profile itself. In most cases, the nighttime consumption dropped, with a steeper increase to daytime levels in the morning and a steeper decrease to nighttime levels in the afternoon.

In looking only at Tables 2-4, and the average hourly profiles, the conclusion can be made that EMCS retrofits at the study sites have been successful. Further study is required to pinpoint the reasons for increased semester/weekend consumption at Stroman and Victoria High Schools, and semester/weekday consumption at Sims Elementary School.

[10] June 1991 - January 1992 (8 month period)
[11] June 1993 - May 1994 (12 month period)
[12] June 1991 - January 1992 (8 month period)
[13] June 1993 - May 1994 (12 month period)
[14] October 1991- April 14, 1994 (30-1/2 month period)
[15] June 1994 - May 1995 (12 month period)
[16] June 1989 - March 1991 (21 month period)
[17] October 1993 - September 1994 (12 month period)
[18] based on post-retrofit period consumption reported in Table 3

**Figure 2a:** ***SHS Semester Average Hourly Profile***

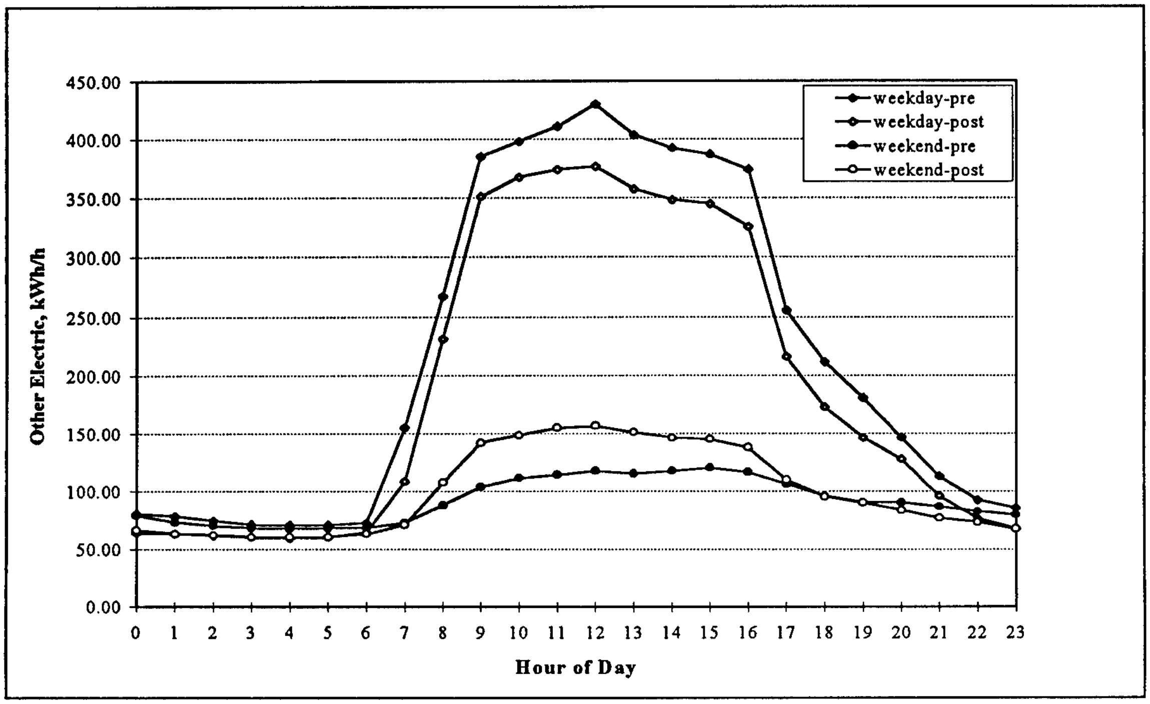



**Figure 2b:** ***SHS Non-semester Average Hourly Profile***

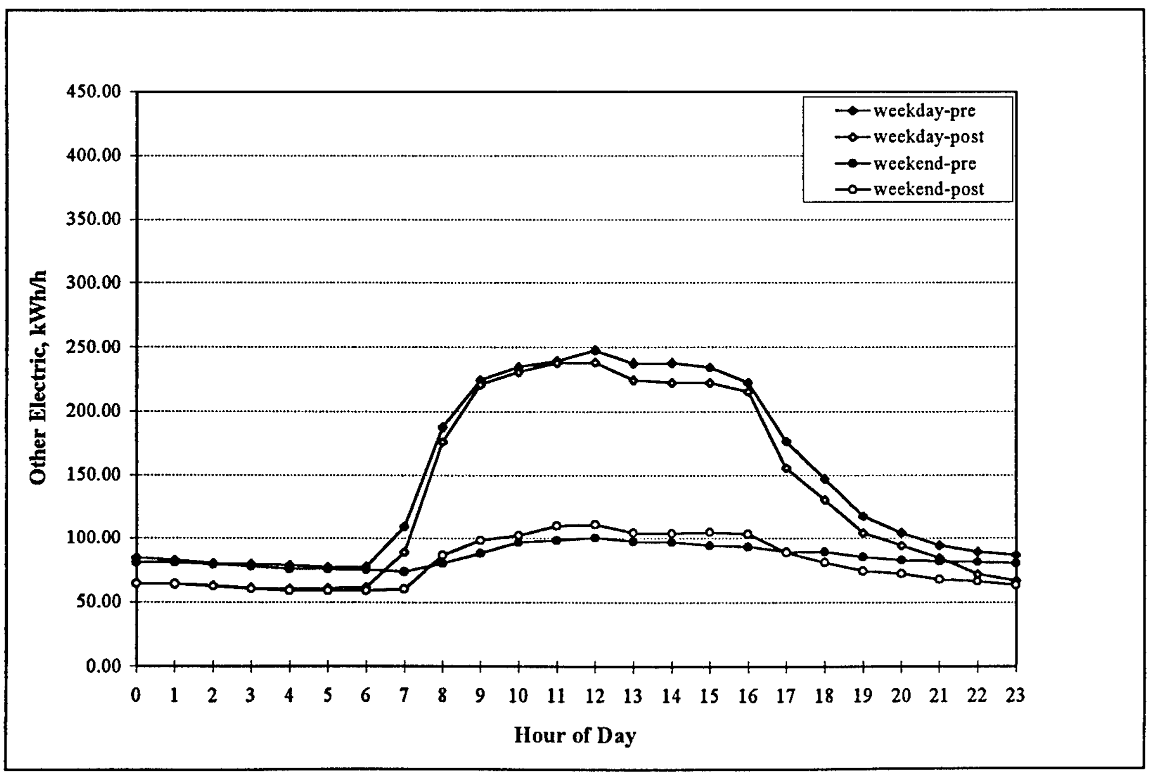


**Figure 3a:** ***VHS Semester Average Hourly Profile***

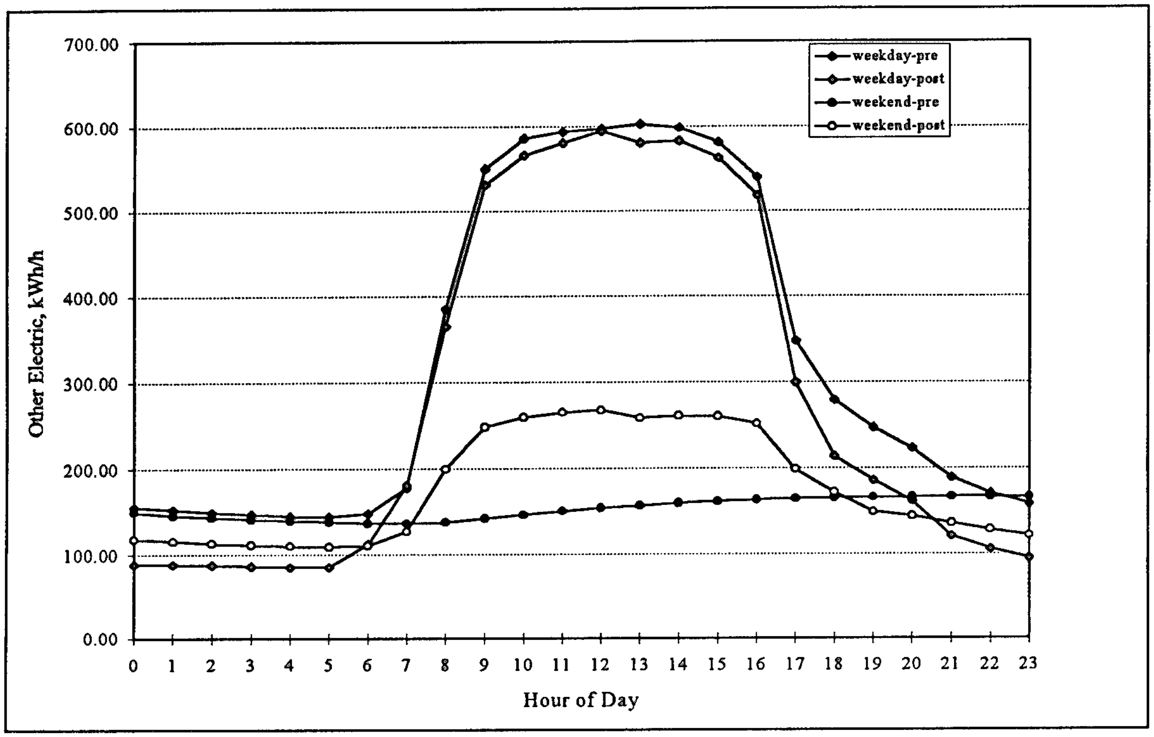



**Figure 3b:** ***VHS Non-semester Average Hourly Profile***

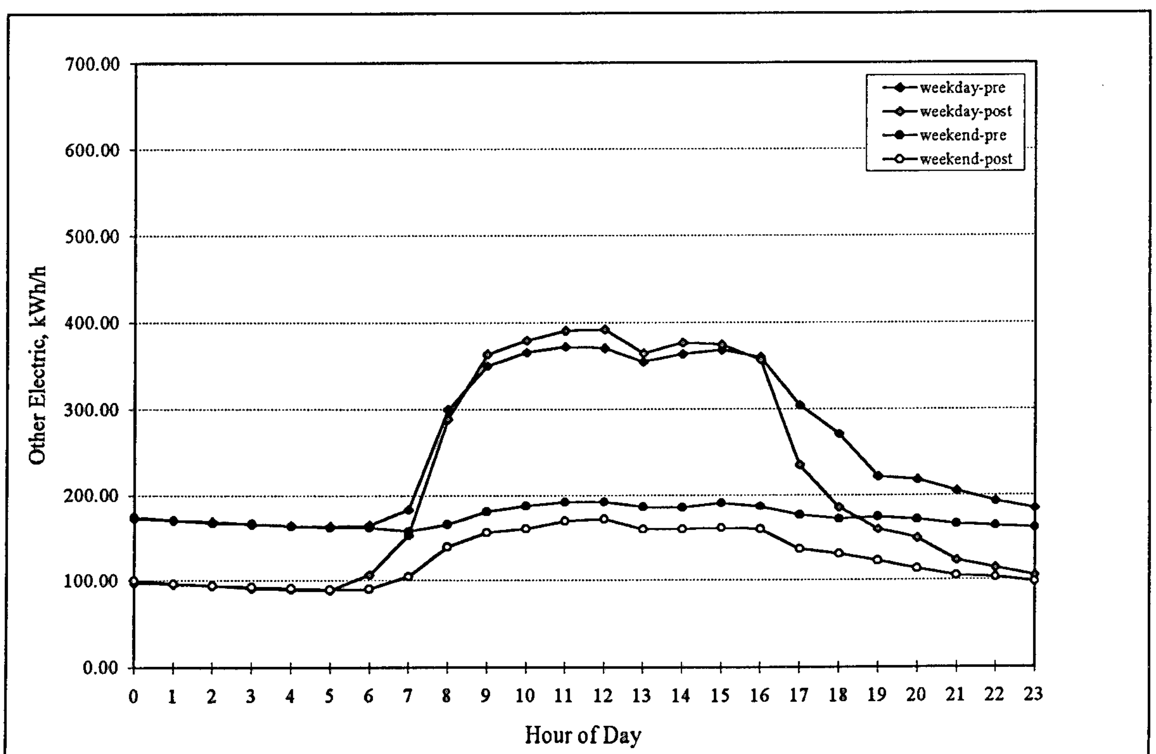


**Figure 4a:** ***SIM Semester Average Hourly Profile***

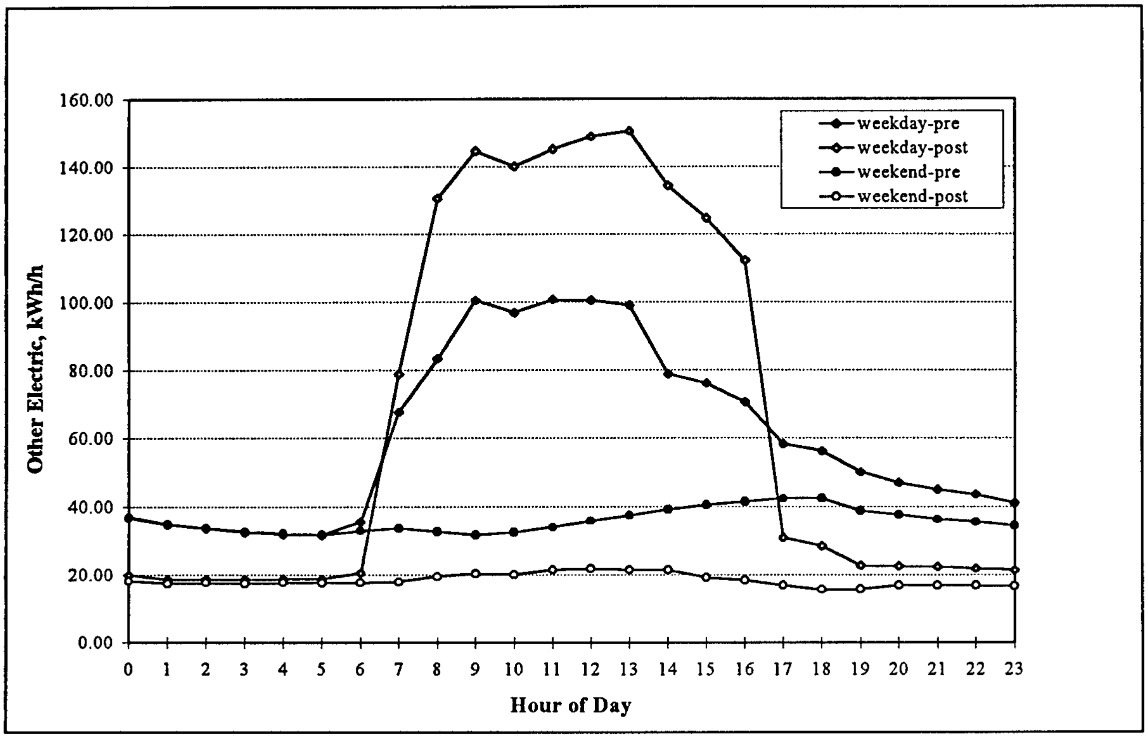



**Figure 4b:** ***SIM Non-semester Average Hourly Profile***

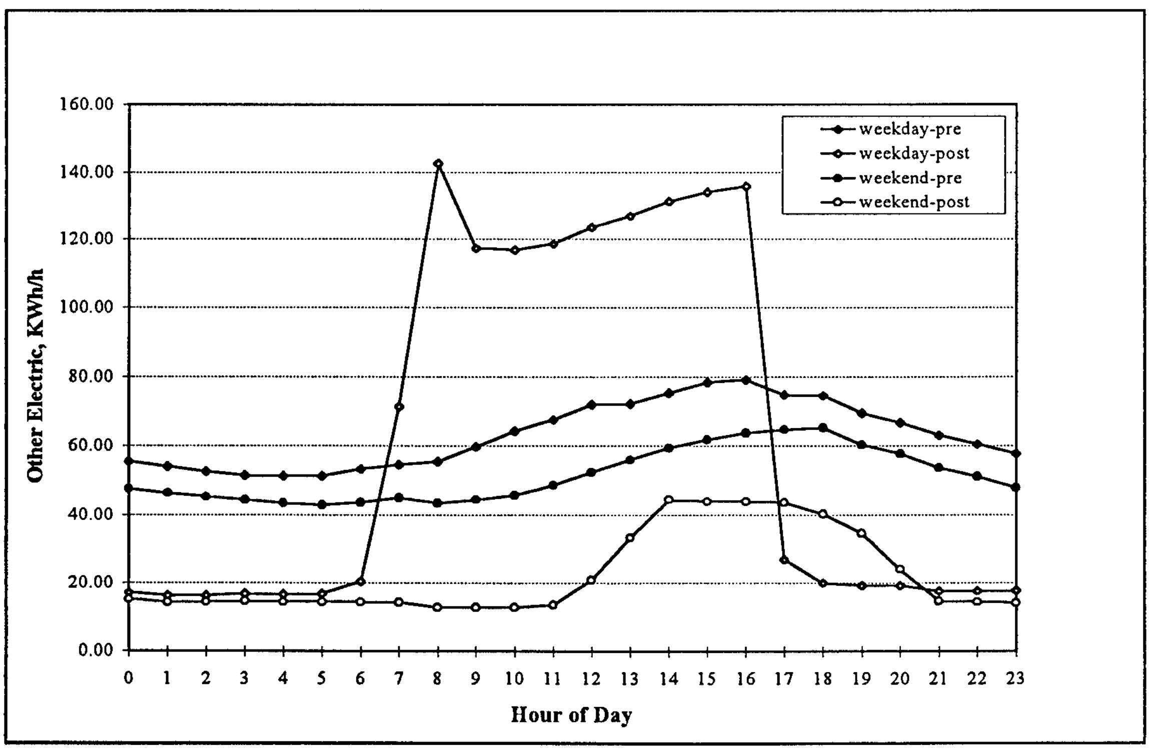
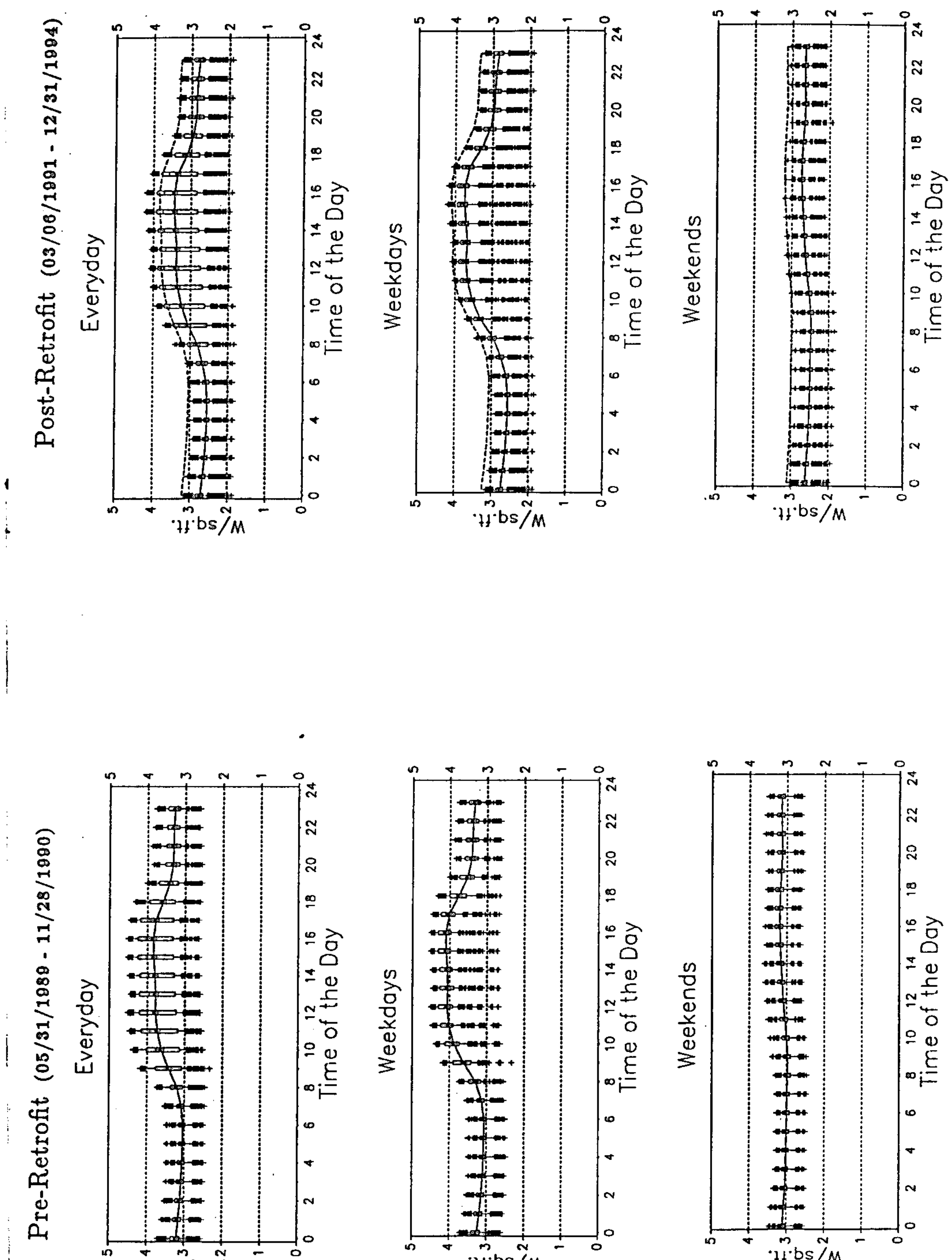


**Figure 5:** ***ZEC Whole Building Electric as W/sf***



# A. STROMAN HIGH SCHOOL

## *A.1 Site Description*[1]

Stroman High School is located in Victoria, Texas. It consists of nine separate buildings with a total floor area of 210,414 square feet. Classrooms are heated and cooled by individual hydronic fan coil units. The first floor is heated and cooled by a hydronic air handler, and there are single air handlers on floors two through four to supply outside air to each floor. The two-story Unit B contains the auditorium, choir room, band room, and drafting classrooms. It is heated and cooled by air handlers. The band hall has direct expansion cooling as well, operating whenever the hydronic air handler does not provide cooling, in order to prevent humidity problems. Unit C is single story, housing the cafeteria and kitchen. It is heated and cooled by hydronic fan-coil units (six in the cafeteria, two in the kitchen). Units D and E are in one contiguous building, a two-story structure containing the library, gymnasium, locker rooms, and the main mechanical room. HVAC is provided by a hydronic air handler in the library, and by heating/ventilation units in the remaining athletic facilities. Unit F is a two-story building containing the science classrooms. It is heated and cooled by hydronic fan-coil units. Unit G is a single story shop building, containing several pieces of electrical equipment, from band saws to drills. It is heated and cooled by direct expansion units with gas furnaces. Chilled water and hot water for units A through G is provided by a 460 ton electric chiller and a 5,050 MBtu gas fired steam boiler. Auxiliary equipment includes a 50 horsepower chilled water pump, a 40 horsepower condenser water pump, a 30 horsepower cooling tower fan, and a 20 horsepower hot water pump.

There are also three athletic buildings just north of the main buildings that house the girls' gym, the field house, and the "athletic dome," in which weight training takes place. All three buildings are heated and cooled by direct expansion units with gas furnace.

[1] Adapted from: Landman, D.S., 1995. "Preliminary Study of Advanced Diagnostic Prescreening Methods," Energy Systems Laboratory, Mechanical Engineering Department, Texas A&M University, College Station, TX.

Air distribution is primarily through single duct multizone systems providing cooling temperatures of approximately 75 °F, and heating temperatures within the range of 70 to 72°F. Heating and air handling systems are turned off completely during the night and are controlled from a central location through a Carrier EMCS.

The school is operated from the middle of August through the middle of May, with approximately 1,529 students and 145 faculty and staff. The maximum school occupancy is from about 8:00 a.m. until 4:00 p.m.; however, the building is occupied for much longer periods, including weekends and summers. Stroman and Victoria High School alternate as the primary location for summer school. Stroman was the site during the summer of 1993. School district calendars for the reporting period of June 5, 1991, through June 4, 1994, are included in Tab A-1.

Large quartz lamps are used to light the tennis courts. These are shut off at 11:00 p.m. Electricity is purchased from Central Power and Light Company, and natural gas from ENTEX Gas Company.

## A.2 EMCS Retrofit

The energy audit for Stroman High School determined that the HVAC operation was controlled manually, which resulted in excessive operating hours in each of the schools within the school district. Timeclock controls were installed many years ago, but were not suited for the needs of the school. See Tab A-2 for the full text technical analysis of the facility that was provided in the audit.

The proposed EMCS retrofit called for the installation of a direct digital control-based EMCS, which would control all HVAC equipment, measure exterior and interior space temperatures, and measure humidity in one or two critical locations within the school. The EMCS would have no override timers that custodial staffs could activate. Operating hours of all HVAC units would be determined by the maintenance staff, and controlled by that staff from its central headquarters via modem.

The EMCS system was installed and activated on January 31, 1992. It controls the HVAC equipment and some lights and measures the temperature and humidity at select locations. Although there are override capabilities, they are not used.

## A.3 Analysis

### A.3.1 Snapshot of consumption for September 1991-December 1993

Figures A-1 and A-2 represent monthly average consumption and peak consumption versus min-max average monthly temperature and peak temperature, respectively.[2]. Min-max average monthly temperature is calculated by averaging the maximum and minimum temperature each day to obtain min-max average daily temperature. The daily temperatures are then averaged over all days in each month to obtain min-max average monthly temperature.

The data points reflecting high temperature and low consumption are indicative of non-semester consumption. If those data points are ignored, there is a general increase of consumption with temperature, indicating a temperature dependence of consumption. Additionally, the post-retrofit data points are generally lower than the pre-retrofit data points. When compared to similar plots for other Texas schools in the LoanSTAR program, this site is a low energy use school. The reader is referred to the referenced report for a more detailed discussion of these plots.

[2] Landman, D.S., 1995. "Preliminary Study of Advanced Diagnostic Prescreening Methods," Energy Systems Laboratory, Mechanical Engineering Department, Texas A&M University, College Station, TX.

**Figure A-1:** ***Monthly Average Consumption:*** **Consumption, in W/sf, versus min-max average monthly temperature, in °F for September 1991 - December 1993 (Stroman High School)**

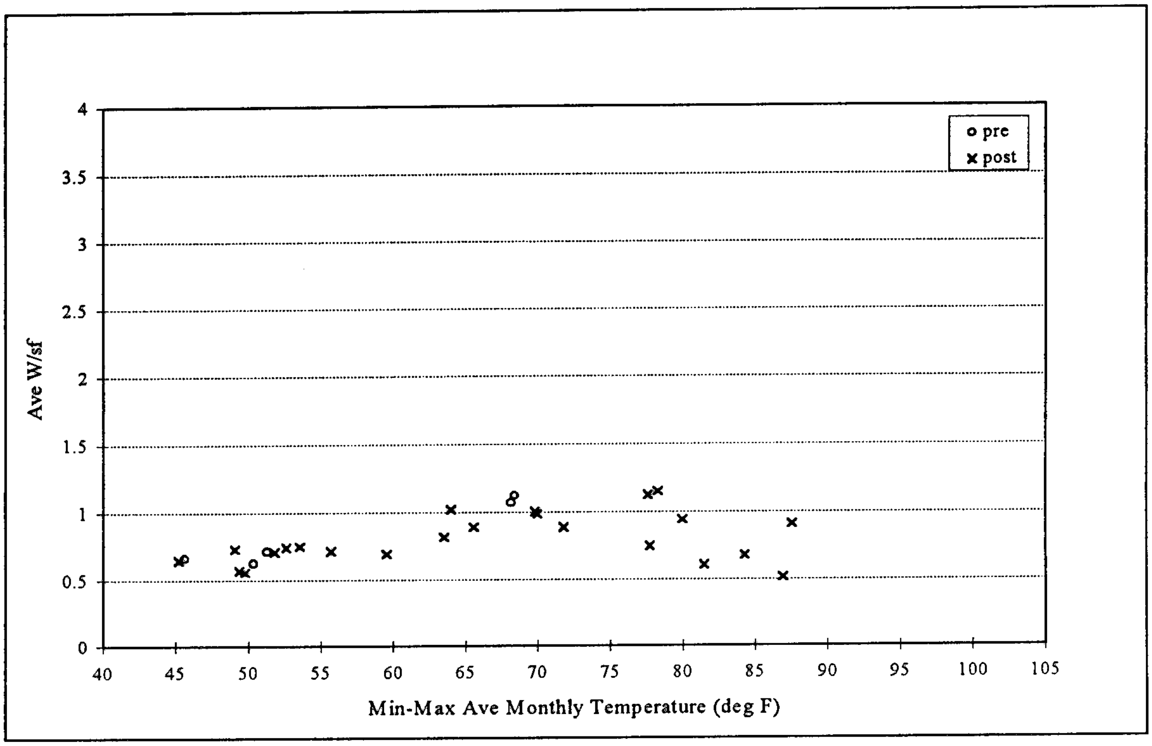
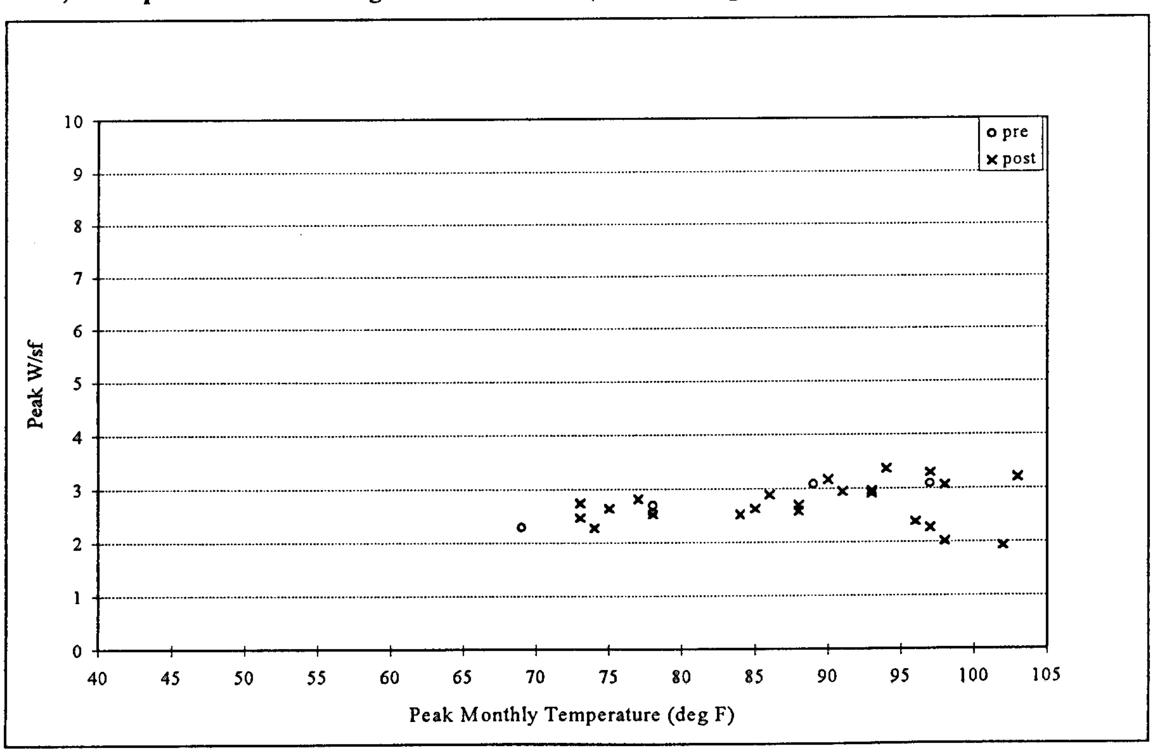



**Figure A-2:** ***Monthly Peak Consumption:*** **Consumption, in W/sf, versus peak monthly temperatures, in °F, for September 1991 through December 1993 (Stroman High School)**



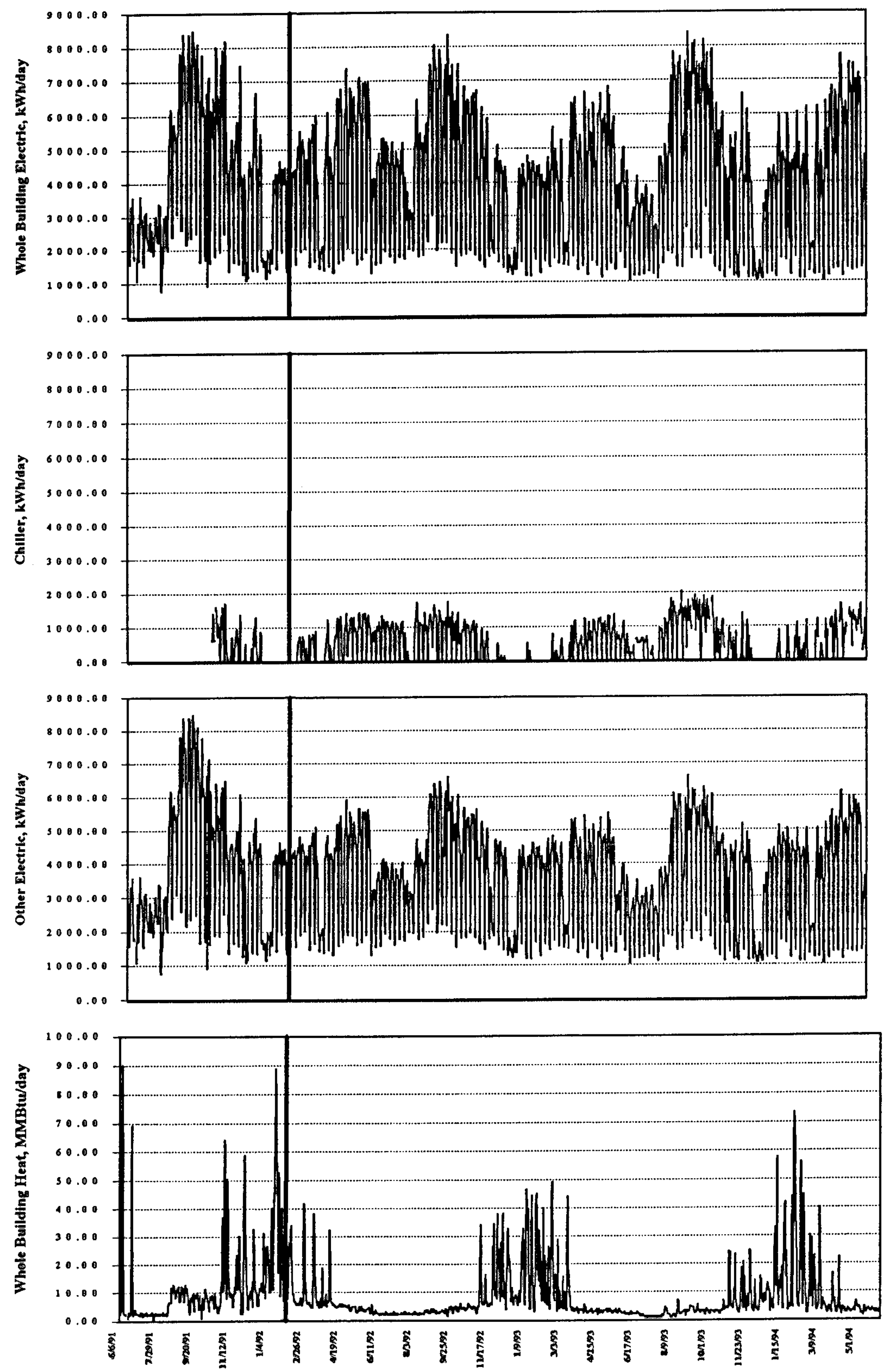
### A.3.2 Timeline plots

Plots of energy consumption for the reporting period are shown in Figure A-3. The EMCS retrofit date of January 31, 1992, is shown by a vertical, bold line. Monitoring diagrams are provided in Tab A-3.

In looking at the whole building electric plot, there is no apparent decrease in consumption at any point along the timeline. There was an absorption chiller installed as a concurrent retrofit at this site. This resulted in the appearance of chiller consumption in September 1991. Any possible decrease in consumption due to the EMCS may have been offset by the increase in consumption due to the new chiller. The appropriate plot to analyze to look at effects due to EMCS only is the "other electric" plot, which is whole building electric minus the absorption chiller. Here a drop in consumption is evident between the pre-retrofit and post-retrofit time periods

The plot of whole building heat shows seasonal heating between November and April of each year. There is also a decrease in consumption evident between the pre-retrofit and post-retrofit periods.

**Figure A-3:** *Energy Consumption time series* **for June 1991 to June 1994 (Stroman High School)**



## A.3.3 Whole Building Electricity Consumption (Post Period)

Table A-1 shows energy consumption for the post-retrofit period (February 1, 1992, through June 4, 1994), broken down by semester and non-semester. Whole building electricity consumption is broken down into two components: chiller electricity consumption and other electricity consumption. The post-retrofit period is used because there is significantly more data available in the that period, and it represents current usage.

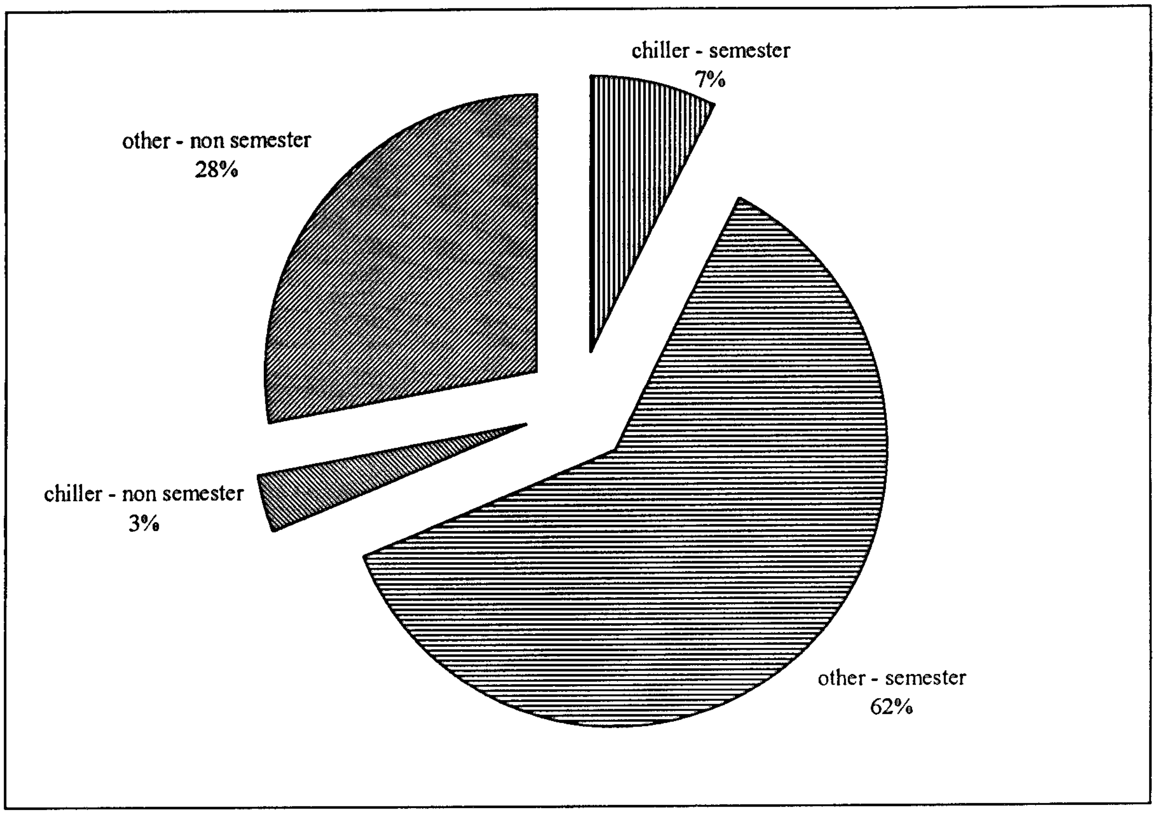
Figure A-4 graphically shows whole building electricity consumption for the post-retrofit period. For the semester period, 62% of whole building electric energy use is attributable to other electric equipment, while 7% is due to the electric chiller. For the non-semester period, other electric accounts for 28% of whole building electric energy, while the chiller accounts for 3%.

For both Table A-1 and Figure A-4, it is readily apparent that chiller consumption accounts for a small portion of the whole building electricity usage. Therefore, attention for reducing energy usage should be focused on the other electricity usage. This is also the reason for focusing attention on other electric consumption in this report. In this case, other electricity consumption is mainly roof-top HVAC units and lighting.

**Table A-1:** ***Energy Consumption*** **for post period, February 1992 - June 1994 (Stroman High School)**

| | SEMESTER | | NON-SEMESTER | | TOTAL | |
|---|---|---|---|---|---|---|
| | ENERGY | $ | ENERGY | $ | ENERGY | $ |
| wbelec, kWh | 2,209,234 | $61,593 | 952,917 | $26,567 | 3,162,150 | $88,161 |
| chlr, kWh | 236,828 | $6,603 | 119,815 | $3,340 | 356,643 | $9,943 |
| other, kWh | 1,972,405 | $54,991 | 833,102 | $23,227 | 2,805,507 | $78,218 |
| wbheat, MMBtu | 5,059 | $24,028 | 1,352 | $6,421 | 64,10 | $30,449 |
| | | | | | | |

**Figure A-4:** ***Whole Building Electricity Consumption*** **for post period, February 1992 - June 1994 Stroman High School**




## A.3.4 Total Monthly Consumption

The total monthly energy consumption is summarized in Table A-2. Again, it is readily apparent that other electric accounts for the majority of this site's electric energy use.

**Table A-2:** ***Monthly Energy Consumption*** **(Stroman High School)**

| | wbelec kWh/month | chiller kWh/month | other kWh/month | wbheat MMBtu/month |
|---|---|---|---|---|
| PRE PERIOD | | | | |
| Jun 91 | 167,040 | 0 | 167,040 | 216 |
| Jul | 181,199 | 24,422 | 156,777 | 437 |
| Aug | 135,033 | 6,361 | 128,672 | 783 |
| Sep | 120,760 | 7,331 | 113,429 | 398 |
| Oct | 140,339 | 16,726 | 123,613 | 274 |
| Nov | 172,213 | 29,039 | 143,174 | 110 |
| Dec | 161,017 | 22,728 | 138,289 | 171 |
| Jan 92 | 130,095 | 6,118 | 123,977 | 571 |
| Total Consumption | 1,207,697 | 112,726 | 1,094,971 | 2,960 |
| Total Cost | $33,671 | $3,143 | $30,528 | $14,059 |
| POST PERIOD | | | | |
| Feb 92 | 123,864 | 999 | 122,865 | 700 |
| Mar | 155,836 | 16,837 | 138,999 | 222 |
| Apr | 178,822 | 32,459 | 146,363 | 104 |
| May | 216,629 | 45,963 | 170,666 | 111 |
| Jun | 145,812 | 13,999 | 131,813 | 287 |
| Jul | 139,191 | 5,025 | 134,166 | 862 |
| Aug | 150,833 | 13,930 | 136,903 | 400 |
| Sep | 193,871 | 34,960 | 158,912 | 107 |
| Oct | 85,113 | 7,833 | 77,280 | 210 |
| Nov | 107,539 | 11,146 | 96,393 | 450 |
| Dec | 126,965 | 16,559 | 110,405 | 183 |
| Jan 93 | 59,302 | 770 | 58,532 | 217 |
| Feb | 61,654 | 6,893 | 54,761 | 133 |
| Mar | 48,803 | 2,534 | 46,269 | 164 |
| Apr | 73,353 | 1,936 | 71,418 | 396 |
| May | 111,118 | 0 | 111,118 | 82 |
| Jun | 113,650 | 2,348 | 111,301 | 406 |
| Jul | 125,016 | 22,649 | 102,366 | 101 |
| Aug | 124,743 | 20,660 | 104,082 | 72 |
| Sep | 125,745 | 18,271 | 107,474 | 199 |
| Oct | 103,438 | 14,459 | 88,979 | 120 |
| Nov | 98,266 | 11,325 | 86,941 | 52 |
| Dec | 164,686 | 33,704 | 130,982 | 105 |
| Jan 94 | 75,544 | 5,414 | 70,130 | 253 |
| Feb | 57,468 | 43 | 57,425 | 149 |
| Mar | 83,609 | 8,992 | 74,617 | 129 |
| Apr | 64,819 | 4,018 | 60,802 | 154 |
| May | 47,334 | 2,034 | 45,300 | 112 |
| Jun 94 | 8,492 | 896 | 7,596 | 11 |
| Total Consumption | 3,171,513 | 356,656 | 2,814,857 | 6,483 |
| Total Cost | $88,422 | $9,944 | $78,478 | $30,795 |
| Grand Total Consumption | 4,379,210 | 469,382 | 3,909,828 | 9,443 |
| Grand Total Cost | $122,092 | $13,086 | $109,006 | $44,854 |

### A.3.5 Average Daily Consumption

Figures A-5a and A-5b depict the average daily consumption for the semester period and the non-semester period. From both plots, you can see that the consumption for the weekdays does not change in profile, but does decrease in magnitude.

For the semester period, Figure A-5a, the weekday consumption decreased substantially during the daytime hours, 7:00 a.m. to 5:00 p.m., and slightly decreased during the nighttime hours, 5:00 p.m. to 7:00 a.m. The weekend consumption decreased during the nighttime, but increased during the daytime hours. Why does the post-retrofit consumption exceed that of the pre-retrofit consumption for weekends? One possible explanation is that the setpoints on the new EMCS are such that the consumption is greater during the weekend than before the EMCS was installed. Another possible explanation may be due to many more data points in the post period, and periodic special events on the weekends. These two factors combined may result in higher weekend daytime consumption in the post period.

For the non-semester period, Figure A-5b, weekday consumption slightly decreased during the daytime hours and greatly decreased during the nighttime hours. Here, the weekend usage changed in a manner similar to that of the weekdays. The changes in both weekday and weekend consumption can be attributed to the EMCS retrofit.

Tab A-4 contains a summary of the hourly averages and the respective standard deviations and count of data points. The hourly averages are the data that is plotted in Figures A-5a and A-5b. For this site, the standard deviations are quite large. They do not vary much between the hours of 0 through 6, then jump to higher levels in hours 7 through 23. This should not be alarming, because the periods that the data were averaged over include wide ranges of temperatures. As was seen earlier, in Figures A-1 and A-2, the energy usage is temperature dependent. The count of data points represents the actual number of data points used to calculate the average, which corresponds to the amount of time that the equipment was actually operating.

**Figure A-5a:** *Semester Pre-/Post-retrofit Consumption* **(Stroman High School)**

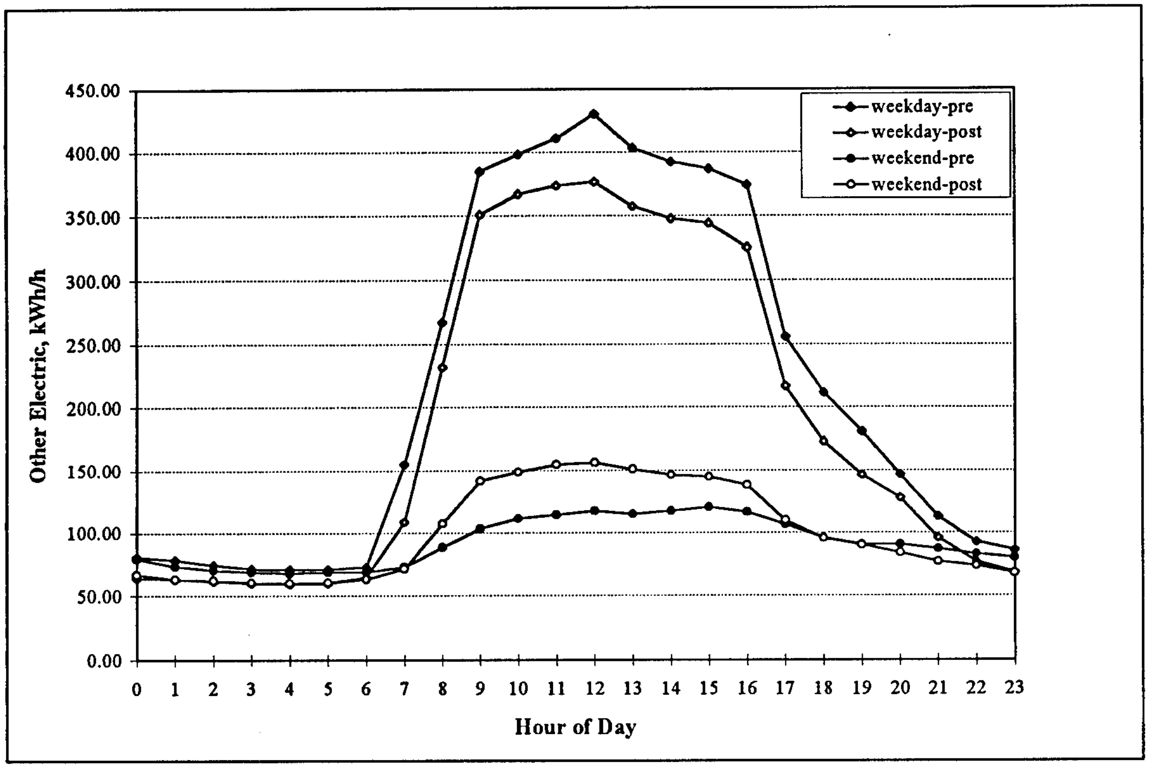
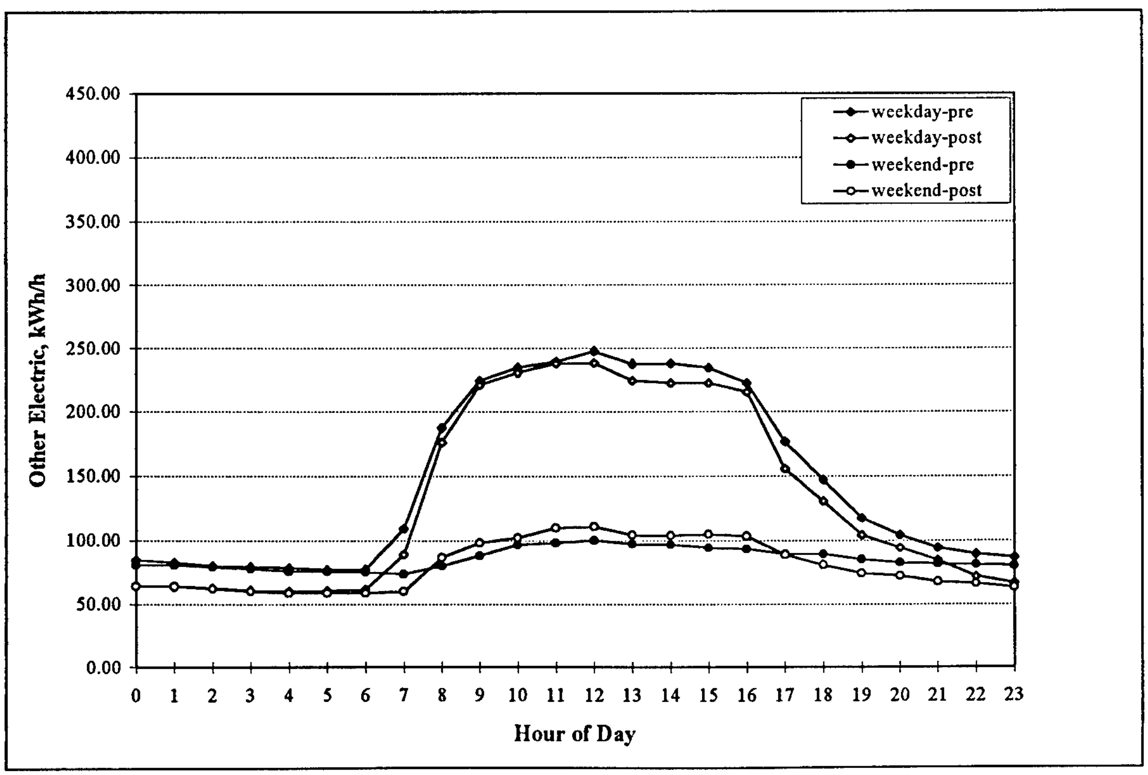



**Figure A-5b:** *Non-semester Pre-/Post-retrofit Comparison* **(Stroman High School)**



The difference in other electric energy consumption was calculated based on the average daily data. This is shown in Table A-3, both as a difference in energy and a percentage difference in energy.

**Table A-3:** ***Reduction in Other Electric Energy Consumption*****, based on average daily data (Stroman High School)**

| | # days in sort category | Average Daily Consumption kWh/day | Difference in Average Daily Consumption kWh/day | % Difference in Average Daily Consumption |
|---|---|---|---|---|
| Semester | | | | |
| weekday-pre | 91 | 5,210 | | |
| weekday-post | 394 | 4,525 | -685 | -13.15% |
| weekend-pre | 35 | 2,206 | | |
| weekend-post | 149 | 2,395 | 189 | 8.57% |
| Non-semester | | | | |
| weekday-pre | 79 | 3,557 | | |
| weekday-post | 241 | 3,225 | -332 | -9.33% |
| weekend-pre | 33 | 2,060 | | |
| weekend-post | 92 | 1,930 | -130 | -6.31% |

There was a reduction in consumption for all categories except semester, weekend. Possible reasons for this increase were discussed in the previous section.

### A.3.6 Plots from MECR

The September MECR energy use plots for four years are shown in Tab A-5. These provide a more qualitative look at the effects of the EMCS. September 1991 is a pre-retrofit plot. Note that there is generally low consumption between the hours of Midnight and 6:00 a.m., with a gradual increase to daytime levels. This is followed by a slow decrease in consumption between the hours of 4:00 p.m. and 10:00 p.m. There are many afternoons and evenings where consumption did not drop to nighttime levels. September 1992 shows a decreased nighttime consumption, with a much sharper slope up to daytime levels between 7:00 a.m. and 8:00 a.m. The consumption drops off much more quickly at 4:00 p.m., as compared to September 1991, indicating that the EMCS is controlling the consumption as expected. There are still a few days with high afternoon and evening consumption, most likely due to special events that required the air conditioning and lighting to remain on after hours. The profiles continue to improve for the months of September 1993 and September 1994.

It should be noted that these profiles only allow a look at weekday data. The weekend data is unreadable from these plots. Separating the data into weekdays and weekends, then plotting separately, would enable one to evaluate weekends, as well as weekdays.

### A.3.7 Data Summary Notebook Information

The Data Summary Notebook information is included in Tab A-6 for information only. It is not analyzed for this site

## Tab A-1

## School District Schedule

# VICTORIA PUBLIC SCHOOLS
## SCHOOL CALENDAR 1990 - 91

| | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JULY | 1 | 2 | 3 | | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | 31 | | | | | |
| AUGUST | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | | | | | | | |
| SEPTEMBER | 1 2 | | <4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | | | | | | | 19 |
| OCTOBER | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15> | <16 | 17 | 18 | 19 | 20 21 | 22 | 23 | | 25 | 26 | 27 28 | 29 | 30 | 31 | | | | 23 |
| NOVEMBER | | | | | 1 | 2 | 3 4 | 5 | 6 | 7 | 8 | 9 | 10 11 | 12 | 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | | | 24 25 | 26> | <27 | 28 | 29 | 30 | | 20 |
| DECEMBER | 1 2 | 3 | | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | | | 22 23 | | | | | | 29 30 | | | | | | | 13 |
| JANUARY | | | | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21> | | <23 | 24 | 25 | 26 27 | 28 | 29 | 30 | 31 | | | 21 |
| FEBRUARY | | | | | | 1 | 2 3 | 4 | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | | 27 | 28 | | | 20 |
| MARCH | | | | | | 1 | 2 3 | 4> | <5 | 6 | 7 | | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | | | | | | 30 31 | 15 |
| APRIL | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | | 17 | 18 | 19 | 20 21 | 22> | <23 | 24 | 25 | 26 | 27 28 | 29 | 30 | | | | | 22 |
| MAY | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | | 28 | 29 | 30 | 31> | | 22 |
| JUNE | 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | | | | | | | |

Total Days 175

**Inservice**
August 27-31
January 22
March 8 - Optional Inservice
June 1

**Bad Weather Days:**
Instruction.........June 3; June 4
Inservice/Preparation...June 5

**Holidays**
July 4 - Independence Day
September 3-Labor Day
November 22-23 - Thanksgiving
December 20-31, Christmas
January 1 New Year
March 25-29 Spring Break
May 27 - Memorial Day

**Reporting Periods**
First Semester Begins ...September 4
First Semester Ends ......January 21

Second Semester Begins..January 23
Second Semester Ends...........May 31

No Appraisal Days

| | |
|---|---|
| Sept. 4-14 | Jan. 2, 14-18 |
| Nov. 21 | Mar. 22 |
| Dec. 19 | May 23-31 |

**Early Dismissal**
October 24
December 4
February 26
April 16
May 31

**Graduation**
Victoria H.S...........June1
Stroman H.S...........May 31

| Six Weeks - Begins | | Ends | |
|---|---|---|---|
| First.......... | September 4 | October 15 | 30 |
| Second....... | October 16... | November 26 | 28 |
| Third......... | November 27. | January 21 | 31 |
| | | 1st Semester | 89 |
| Fourth....... | January 23... | March 4 | 29 |
| Fifth.......... | March 5.. | April 22 | 29 |
| Sixth......... | April 23........ | May 31 | 28 |
| | | 2nd Semester | 86 |
| | | **Total** | 175 |

# VICTORIA PUBLIC SCHOOLS
## SCHOOL CALENDAR 1991- 1992

| | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 JULY | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | 29 | 30 | 31 | | | | |
| AUGUST | | | | | 1 | 2 | 3 4 | 5 | 6 | 7 | 8 | 9 | 10 11 | 12 | 13 | 14 | 15 | 16 | 17 18 | 19 | [illegible] | [illegible] | <22 | 23 | 24 25 | 26 | 27 | 28 | 29 | 30 | 31 | 7 |
| SEPTEMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | | | | | | 20 |
| OCTOBER | | | 1 | 2 | 3 | 4 | 5 6 | 7> | <8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 | 29 | 30 | 31 | | | 23 |
| NOVEMBER | | | | | | 1 | 2 3 | 4 | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18> | <19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 | 19 |
| DECEMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | 31 | | | | | 15 |
| 1992 JANUARY | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16> | [illegible] | 18 19 | <20 | 21 | 22 | 23 | 24 | 25 26 | 27 | 28 | 29 | 30 | 31 | | 19 |
| FEBRUARY | 1 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 | | | | | | | 20 |
| MARCH | 1 | 2> | <3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | [illegible] | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | 31 | | | | | 16 |
| APRIL | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16> | 17 | 18 19 | 20 | <21 | 22 | 23 | 24 | 25 26 | 27 | 28 | 29 | 30 | | | 20 |
| MAY | | | | | | 1 | 2 3 | 4 | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 31 | 21 |
| JUNE | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | 29 | 30 | | | | | |

**TOTAL DAYS 180**

**Inservice/Preparation Dates**

August 20-21
January 17
March 13 Effective Schools
May 30

**Bad Weather Days:**

April 20
June 1

**Holidays**

July 4 - Independence Day
September 2 - Labor Day
Nov. 27 (1/2)-29 - Thanksgiving
December 20 (1/2) January 3
Christmas, New Year
March 16-20 - Spring Break
April 17 - 20 Easter

**Appraisal Periods**

1st Appraisal Period (Level 1)
September 5-January 10
1st Appraisal Period (Level 2,3, 4)
September 5-May 20
2nd Appraisal Period (Level 1)
January 20-May 20

**No Appraisal Days**

Aug. 21-Sept. 4
Nov. 26
Dec. 20
Jan. 13-16
April 16
May 21-29

**Early Dismissal**

October 23
Nov.27 (Early Release Day)
Dec. 20 (Early Release Day)
April 28
May 29

**Graduation**

VHS....May 29
SHS....May 30

| Six Weeks - | Begins | Ends | |
|---|---|---|---|
| First.......... | August 22....... | October 7 | 32 |
| Second....... | October 8... | Nov. 18 | 30 |
| Third........: | November 19.. | January 16 | 31 |
| 1st Semester | Aug. 22-Jan. 16 | | 93 |
| Fourth....... | January 20.... | March 2 | 31 |
| Fifth.......... | March 3......... | April 16 | 27 |
| Sixth......... | April 21....... | May 29 | 29 |
| 2nd Semester | Jan. 20-May 29 | | 87 |
| | | Total | 180 |

Revised June 20, 1991

# VICTORIA PUBLIC SCHOOLS
## SCHOOL CALENDAR 1992 - 93

| | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 JULY | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | 27 | 28 | 29 | 30 | 31 | | |
| AUGUST | 1 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | < 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | 31 | | | | | | 9 |
| SEPTEMBER | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 > | < 29 | 30 | | | | 21 |
| OCTOBER | | | | | 1 | 2 | 3 4 | 5 | 6 | 7 | 8 | 9 | 10 11 | 12 | 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | 22 | 23 | 24 25 | 26 | 27 | 28 | 29 | 30 | 31 | 22 |
| NOVEMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 > | < 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | | | | | | 19 |
| DECEMBER | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 | 29 | 30 | 31 | | | 14 |
| 1993 JANUARY | | | | | | 1 | 2 3 | 4 | < 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 31 | 19 |
| FEBRUARY | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 > | < 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | | | | | | | 19 |
| MARCH | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | 29 | 30 | 31 | | | | 18 |
| APRIL | | | | | 1 | 2 | 3 4 | 5 | 6 | 7 | 8 > | 9 | 10 11 | 12 | < 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | 22 | 23 | 24 25 | 26 | 27 | 28 | 29 | 30 | | 20 |
| MAY | 1 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | 31 | | | | | | 19 |
| JUNE | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 | 29 | 30 | | | | |

Total Days 180

**Inservice**
August 17-18
January 4
Feb. 15 Effective Schools
May 28

**Bad Weather Days**
April 12
May 29

**Holidays**
July 4 - Independence Day
September 7 - Labor Day
November 25(1/2)-27
Thanksgiving
December 18(1/2)-January 1
Christmas, New Year
March 15-19 - Spring Break
April 9-12 - Easter

**Appraisal Period**
1st Appraisal Period (Level 1)
September 2 - January 8
1st Appraisal Period (Level 2,3,4)
September 2 - May 21
2nd Appraisal Period (Level 1)
January 11 - May 21

**No Appraisal Days ***
August 19 - September 1
November 24
December 14 - 17
April 8
May 3 - 27
(except for 3rd appraisals)

**Early Dismissal**
September 15
October 12
November 25
(Early Release Day)
December 18
(Early Release Day)
April 28
May 27

**Graduation**
SHS.....May 27
VHS.....May 28

| Six Weeks - Begins | | Ends | |
|---|---|---|---|
| First.......... | Aug. 19 | Sept. 28 | 28 |
| Second....... | Sept. 29 | Nov. 9 | 30 |
| Third......... | Nov. 10 | Dec. 18 | 27 |
| **1st Semester** | | | |
| **August 19 - December 18** | | | 85 |
| Fourth..... | Jan. 5 | Feb. 16 | 30 |
| Fifth........ | Feb. 17 | Apr. 8 | 32 |
| Sixth....... | Apr. 13 | May 27 | 33 |
| **2nd Semester** | | | |
| **January 5 - May 28** | | | 95 |
| | | TOTAL | 180 |

*Revised 6-92

# VICTORIA PUBLIC SCHOOLS

School Calendar 1993-1994

| | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1993 JULY | | | | | 1 | 2 | 3 4 | [illegible] | 6 | 7 | 8 | 9 | 10 11 | 12 | 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | 22 | 23 | 24 25 | 26 | 27 | 28 | 29 | 30 | 31 | |
| AUGUST | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | [illegible] | [illegible] | <18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | 31 | | | | | 10 |
| SEPTEMBER | | | | 1 | 2 | 3 | 4 5 | [illegible] | [illegible] | [illegible] | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | 27 | 28> | <29 | 30 | | | 19 |
| OCTOBER | | | | | | 1 | 2 3 | 4 | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 31 | 21 |
| NOVEMBER | | 1 | 2 | 3 | 4> | <5 | 6 7 | 8 | 9 | 10 | [illegible] | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22 | 23 | [illegible] | [illegible] | [illegible] | 27 28 | 29 | 30 | | | | | 19 |
| DECEMBER | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | [illegible] | 18 19 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 25 26 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | 13 |
| 1994 JANUARY | 1 2 | [illegible] | [illegible] | [illegible] | <6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | 31 | | | | | | 18 |
| FEBRUARY | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17> | <18 | 19 20 | [illegible] | 22 | 23 | 24 | 25 | 26 27 | 28 | | | | | | 19 |
| MARCH | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | [illegible] | 12 13 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 | 29 | 30 | 31 | | | 17 |
| APRIL | | | | | | [illegible] | 2 3 | [illegible] | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14> | <15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 | 19 |
| MAY | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27> | 28 29 | 30 | 31 | | | | | 20 |
| JUNE | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | 27 | 28 | 29 | 30 | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Total | 175 |

**Inservice**

September 7-8
January 4-5
February 21
March 11

**Workdays**

August 16-17
January 3
May 28

**Holidays**

July 5 – Holiday
September 6 – Labor Day
November 11 – Veteran's Day
November 24 (1/2)-26 Thanksgiving
December 17 (1/2)-31 Christmas
March 14-18 – Spring Break
April 1-4 – Easter

**Bad Weather Days**

April 4
May 28

**Appraisal Period**

1st Appraisal Period (Level 1)
September 1 - January 21
1st Appraisal Period (Level 2, 3, 4)
September 1 - May 6
2nd Appraisal Period (Level 1)
January 24 - May 6

**No Appraisal Days**

August 18-31
September 3
November 10
November 23-24
December 16-17
March 10, 31
May 9-27

**Early Dismissal**

November 24
(Early Release Day)
December 17
(Early Release Day)

**Graduation**

Victoria High School May 26
Stroman High School May 27

| Six Weeks | Begins < | Ends > | |
|---|---|---|---|
| First | August 18 | September 28 | 27 |
| Second | September 29 | November 4 | 27 |
| Third | November 5 | December 17 | 28 |
| 1st Semester | August 18 - December 17 | | 82 |
| Fourth | January 6 | February 17 | 31 |
| Fifth | February 18 | April 14 | 31 |
| Sixth | April 15 | May 27 | 31 |
| 2nd Semester | January 6 - May 27 | | 93 |
| | | TOTAL | 175 |

# Tab A-2

## Audit Technical Analysis

# TECHNICAL ANALYSIS OF FACILITY

## ECRM DESCRIPTIONS AND CALCULATIONS

**Facility Name:** All Schools

**ECRM No.:** 1

**ECRM Name:** Energy Management System

a. **Summary**

| | | |
|---|---|---|
| Kwh savings: | 1,583,682 | Kwh/yr |
| Demand savings: | 898 | KW-mo/yr |
| MCF savings: | 3,850 | MCF/yr |
| Cost savings: | $95,254 | /yr |
| Implementation cost: | $380,980 | |
| Simple payback: | 4.0 | years |

b. **Description**

On/Off and temperature control in all of the Victoria ISD schools addressed in this report are inadequate. Typically, on/off controls consist of a) 7-day timeclocks which are controlled manually, b) manual control at thermostats or wall switches, and c) programmable thermostats in a very few locations, installed in the last two years. The great majority of on/off control is performed manually, with the result that operating hours are excessive in every school. There is not a single school addressed in this report where on/off control for the majority of HVAC equipment is performed automatically.

Timeclock controls were installed many years ago and are not suited for the needs of the schools.

- There is no way to enforce rigorous hours of HVAC operation if the custodial staff has access to all timeclocks. Even if the timeclocks were functioning with their trippers and the timeclock cabinet were locked, override timers on the face of the timeclock cabinets would allow custodians to turn on HVAC units. The custodians work typically until 9 PM. The natural human tendency is to keep the units on to maintain most comfortable working conditions. Custodial staffs have been instructed on several occasions by the VISD maintenance staff to turn off HVAC promptly after school. Without direct and continuous supervision, one cannot reasonably expect the custodial staff to do so. And they don't.
- The timeclocks offer little flexibility. They typically control multiple HVAC units on one circuit. Often, an entire bank of HVAC units operates when in fact not all are needed. Special events may at time be held outside of normal operating hours. The existing override timers also control banks of units, so -- if the timeclocks and override timers were even used -- more units would operate than necessary.
- There is no feedback with the timeclock system, such as space temperature or humidity readings, and actual operating status of the unit. In several cases, air conditioning takes place 24 hours per day in order to prevent humidity-related problems. Also, heating units may be left on overnight when weather is cold, maintaining temperatures at comfort conditions. Feedback information on space versus outdoor conditions could save a great deal of energy by reducing operating hours.

Summer operation of HVAC systems is also excessive. Schools are cleaned over a period of several weeks during each summer. Depending upon school size, the number of people cleaning, whether summer school is held or not, and the type of cleaning projects taking place, the cleaning process can take up to 6 weeks or more. Often the cleaning crews will turn on air conditioning for entire schools or wings of schools, regardless of how many rooms are actually being cleaned, since the method of turning units on is to flip a master timeclock switch which turns on whole banks of units. Again, virtually all control is manual through thermostats or timeclock master trippers. In addition to air conditioning schools for personal comfort, the cleaning crew operates the air conditioning to speed up drying of floors and other surfaces cleaned. Also, some teachers start coming to school by mid August. Typically, air conditioning throughout an entire school is again turned on, even though the number of teachers occupying the school is very small.

Temperature controls are virtually all open to occupant adjustment. The number of locking thermostats in all schools addressed in this report can be counted on one hand, and some of those are not locked. Typical settings are in the low 70's (deg F).

Even the programmable thermostats of the most recently installed HVAC units offer less than ideal control. The units inspected were programmed for 6 AM to 6 PM operation. While this schedule covers most occupancy demands, it is generally excessive. Neither teachers nor staff reprogram the thermostats as their occupancy needs differ.

Though the quantity of timeclocks and HVAC units may vary by school, the control methodology described above is typical of all the schools in this report. Controls in each school are addressed individually below. A summary of On/Off times follows (as determined by interviews with custodial staffs), starting on page 80.

<u>Aloe Elementary</u>

There are four timeclocks located in a small janitorial room in the main wing. Each is a 7-day timeclock. Clock #1 controls the library unit, #2 the kitchen, #3 the offices and classrooms, and #4 the cafeteria units. There are override toggle switches in the face of the timeclock cabinet, one for each timeclock. However, as the timeclocks are not used as originally intended, the overrides are useless. On each timeclock, on/off trippers have been removed, and the custodial staff uses the master on/off tripper to control units. All units are turned on manually by custodians at about 6:30 - 7:00 AM. The custodial staff works after school until 9 PM, and turns the units off when they leave.

In the 3rd/4th grade wing and the kindergarten wing, programmable thermostats have been installed. On/off times are 6 AM to 6 PM, Monday through Friday.

<u>De Leon Elementary</u>

There are two timeclock stations in the school. The first station, located behind the library, has four 7-day timeclocks. The second station, located in an electrical room in the south classroom wing, has three 7-day timeclocks. There is an override toggle switch for each timeclock. These seven timeclocks control the seven rooftop HVAC units installed with the original school. HVAC units 8 - 11 were added with the new classroom addition. They are controlled directly from individual room thermostats, not by timeclock.

All units are controlled manually by the custodial staff using the timeclock master on/off tripper, and room thermostats. Operating hours are from 6 AM until 8 PM.

Dudley Elementary

There are three 7-day timeclocks located in the electrical room across the hall from the cafeteria. The first controls classroom and office units, the second the kitchen, and the third the cafeteria. All units are controlled manually by the custodial staff using the timeclock master on/off tripper. On/off hours are typically 7 AM to 7 PM, Monday through Friday.

Hopkins Elementary

There are four rooms which contain timeclocks at Hopkins. The main mechanical room has four 7-day timeclocks, controlling direct expansion units for 1) the office area, 2) the library, 3) the kitchen, and 4) the cafeteria. There is a single 7-day timeclock in the north wing, one in the south wing, and one in the middle wing. Each controls HVAC fan-coil units and chillers/pump for their respective wing. Most or all trippers have been removed from all timeclocks, and all are operated manually.

All units are turned on manually by custodians at about 6:00 AM. The custodial staff works after school until 9 PM, and turns the units off when they leave.

Howell Intermediate

There is a main control panel at Howell Intermediate located in the main mechanical room. Toggle switches are located in the face of the panel for controlling virtually all HVAC units in the school. When the custodian arrives at 6:30 AM, he turns on all HVAC units via the toggle switches, and the chiller if necessary. He always turns on the boiler, no matter what the weather conditions, since the HVAC system at Howell is reheat. Another custodian turns off HVAC equipment around 7 PM.

In summer, the same procedure is followed for the approximately six weeks cleaning period.

Juan Linn Elementary

All HVAC units installed with the 1986 addition are controlled by programmable thermostats. Programmed on/off times are 6 AM on, and 6 PM off, Monday through Friday. The one exception is the library unit. It has a programmable thermostat, but the unit remains in operation continuously out of concern for mildew on library books. The two rooftop units over the original (east) classroom wing have been replaced recently, and are controlled by programmable thermostats also.

All fan-coil units and the chiller of the stand-alone 1951 addition are controlled by 7-day timeclock located by the east entrance to the building. All trippers to the clock have been removed. The janitor operates the master timeclock tripper to control HVAC.

In the main building, the custodian turns units on manually at the thermostats when she arrives at 6:45 AM, and another custodian turns units off around 8 PM.

Summer school is held in Juan Linn for six weeks. Again, custodians turn equipment on/off manually. However, most units are turned off earlier in the day as compared to the regular school year.

O'Connor Elementary

Two rooms contain 7-day timeclocks at O'Connor, one in the north wing and one in the south. All units are turned on manually by custodians at about 6:30 AM, and off at around 8:00 PM. The east wing addition units are controlled manually by custodians via their thermostats.

There are two locking thermostats in the north wing, but neither was locked when seen.

Shields Elementary

The majority of floor area in Shields is served by hydronic fan-coil units. Control is the same as in all other elementaries: 7-day timeclocks exist, but custodial staff uses only the master trippers to turn units on and off when they arrive and depart. Units are turned on around 7 AM, and off about 6:30 PM.

Stanly Elementary

Control of HVAC units in Stanly is identical to O'Connor. The two schools originally had identical floor and HVAC plans. Timeclocks are located in exactly the same rooms as in O'Connor.

Stroman High School

Control of HVAC units at Stroman requires very intensive footwork. The custodian makes rounds to every air handling unit, most fan-coil units, many direct expansion units, and the chiller/boiler/auxiliary equipment each morning around 6:45 AM, where he turns equipment on. Another custodian makes a similar round at about 8:30 PM to turn equipment off.

The kitchen staff turns kitchen HVAC on and off. The coaching staff turns athletic building HVAC off, and the custodial staff turns it back on in the morning, though often the coaching staff forgets to turn units off.

A small (46 ton) reciprocating chiller is located adjacent to the four story Unit A. This chiller is piped to serve only Unit A. During summer and after school hours, parts of Unit A (which contains administrative offices) are the only occupied portions of the school. At 4:30 PM during the school year, the absorption chiller is shut down and the reciprocating chiller is turned on, and continues to operate until 9 PM. In summer, the reciprocating chiller is turned on 7:00 AM, and off at 6:00 PM, unless the main chiller is operating.

Direct expansion split systems serving the Band hall are thermostatically controlled, but are left in operation continuously, summer and winter. If the main air handler serving Band has been shut off and indoor temperature starts to rise, the DX units will maintain humidity and temperature conditions. These backup DX units were installed out of concern for humidity-related problems with Band instruments.

Summer cleaning of the high school takes about 5 to 6 weeks. During this time, the main absorption chiller operates every day, and virtually the entire school is cooled. Cleaning is finished by mid- to late-July, and only the reciprocating chiller operates after that.

Victoria High School

Victoria High is another school requiring intensive footwork in turning HVAC systems on and off. The VHS campus contains numerous buildings spread out over a wide geographical area. The maintenance man starts his round at 7 AM to all mechanical rooms and thermostats/wall switches, turning on equipment. As at Stroman, the coaching staff is responsible for turning off some athletic building HVAC equipment (though they often forget) and the maintenance man turns it back on in the morning.

There are two rooftop units over the Learning Resource Center. During the regular school year, these operate from 7:15 AM until 4 PM. During summer, one of the units is shut down, but the other remains in operation 24 hours per day to prevent problems with mildew. Starting in September, HVAC for the boys dressing room is left on continuously until cold weather hits, so as to reduce odor problems which are worsened by heat and humidity.

Summer school is held in the Academic Wing of VHS, and occasionally in the main wing. The Academic Wing is served by the absorption chiller. The chiller is turned on at 6:30 AM, and off at 1:30 PM. The fan-coil units served by the chiller remain in operation continuously, both summer and winter. The on/off switches for them are located inside the units.

Fan-coil units for the main building are controlled by toggle switches mounted on the wall of each classroom. Teachers are supposed to turn these units off as they leave each day, and the maintenance staff turns them back on in the morning. However, as often as not, the fan-coil units are left on at night.

This ECRM calls for the installation of a direct digital control-based energy management system (EMS) for each school addressed in this report. The EMS will control all HVAC equipment, measure exterior and interior space temperatures, and measure humidity in one or two critical locations within each school. The EMS will have no override timers that custodial staffs can activate. Operating hours of all HVAC units will be determined by the maintenance staff, and controlled by that staff from its central headquarters via modem. (Floor plans on pages 27 through 37 show locations of the units to be controlled, and the proposed locations of new DDC controllers).

## Tab A-3

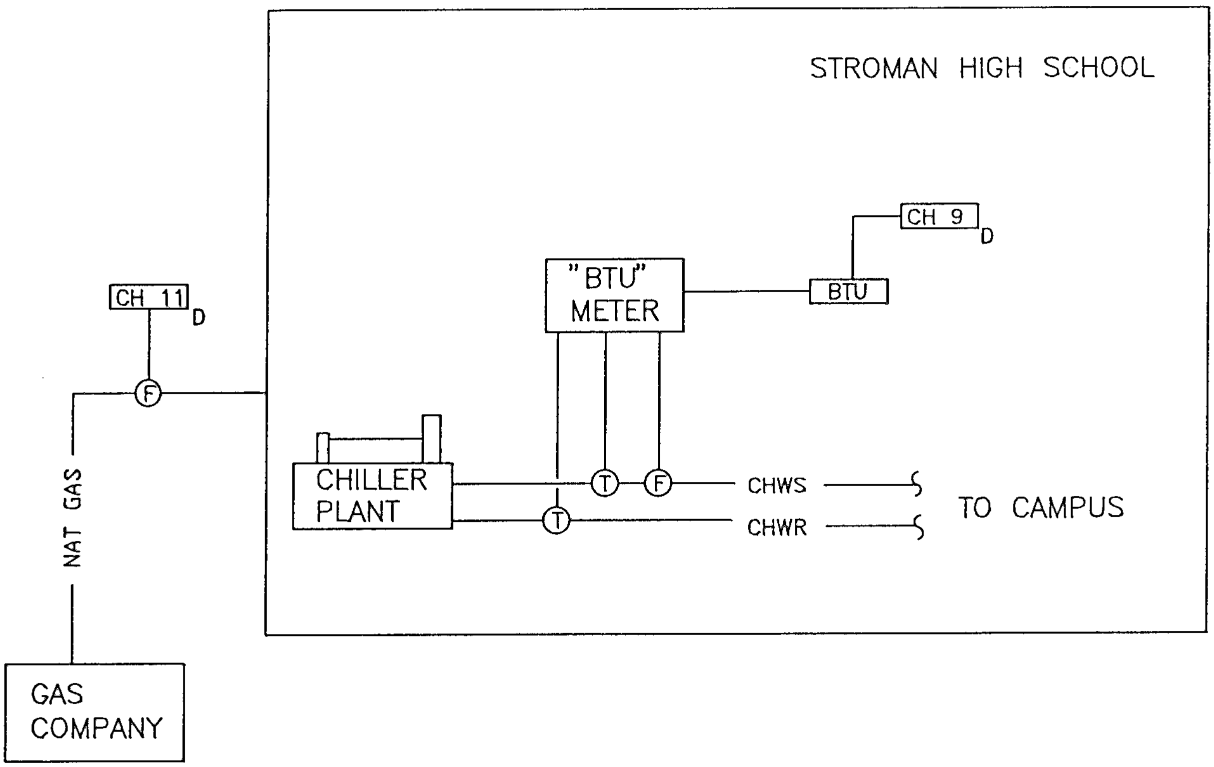
## Monitoring Diagrams

# THERMAL MONITORING DIAGRAM

## VISD – STROMAN HS

LEGEND

K=KWH CHANNEL
A=ANALOG CHANNEL
D=DIGITAL CHANNEL
PC=PUMPED CONDENSATE




VISD/STROMAN HS – SITE 126

## Tab A-4

## Average Hourly Data & Related Statistics

**Hourly Averages**

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 80.6011 | 78.0633 | 74.0433 | 71.1233 | 70.8833 | 70.8022 | 72.5367 | 155.2256 | 267.5822 | 384.9000 | 398.2044 | 411.1200 | 430.2467 | 403.8189 | 392.5822 | 387.1378 | 374.1811 | 255.8758 | 211.8505 | 180.9022 | 146.8330 | 113.0824 | 92.5396 | 85.8571 |
| 1-B-S | 64.1596 | 63.1154 | 61.6433 | 60.1218 | 59.5119 | 60.0570 | 64.6301 | 108.8884 | 231.9041 | 351.1770 | 367.3906 | 373.8428 | 376.8638 | 357.4618 | 348.1329 | 344.8428 | 325.7368 | 216.7218 | 173.4122 | 146.4762 | 128.0020 | 95.9694 | 76.7127 | 68.1843 |
| 0-A-S | 78.9333 | 73.3833 | 70.3167 | 68.4194 | 67.8028 | 68.3528 | 68.5389 | 72.6417 | 88.1611 | 103.7972 | 111.5528 | 114.4694 | 117.5639 | 115.2528 | 117.5611 | 120.5500 | 116.4500 | 106.5056 | 95.9083 | 90.2139 | 90.3583 | 86.6972 | 82.5778 | 79.7972 |
| 0-B-S | 66.5747 | 63.3799 | 62.2280 | 60.4800 | 60.0933 | 60.5607 | 63.0227 | 71.1180 | 107.7053 | 142.1427 | 148.7100 | 155.0487 | 156.7340 | 151.0147 | 146.6233 | 144.9127 | 138.0960 | 110.2160 | 95.2000 | 89.9687 | 83.7280 | 76.8107 | 73.2980 | 67.4567 |
| 1-A-NS | 85.1342 | 83.0763 | 80.4013 | 79.9724 | 78.7816 | 77.5053 | 78.2895 | 109.5289 | 187.6539 | 224.4080 | 235.1095 | 239.2440 | 247.8920 | 237.6987 | 238.1434 | 234.3675 | 222.6675 | 176.9792 | 147.2338 | 117.2662 | 104.6844 | 94.7065 | 89.8286 | 86.8545 |
| 1-B-NS | 65.0865 | 64.2107 | 62.8326 | 61.1819 | 60.2935 | 60.8437 | 62.0144 | 89.6791 | 176.4423 | 220.9595 | 230.6405 | 237.9753 | 238.3265 | 224.7019 | 222.6851 | 222.2614 | 215.5260 | 155.6721 | 130.5860 | 104.7237 | 94.4340 | 85.1660 | 71.7665 | 66.8981 |
| 0-A-NS | 80.9794 | 80.8176 | 79.5794 | 77.8824 | 75.8559 | 76.1265 | 75.3559 | 73.8912 | 80.2853 | 88.5794 | 97.1147 | 98.6029 | 100.7059 | 97.1588 | 97.0118 | 94.6206 | 93.7235 | 89.3912 | 89.7735 | 85.3735 | 83.0324 | 82.0471 | 81.6118 | 80.5765 |
| 0-B-NS | 64.4796 | 64.0624 | 62.2215 | 60.0720 | 58.8656 | 59.0548 | 59.0452 | 60.6452 | 86.8086 | 98.3871 | 102.5828 | 110.1043 | 111.0613 | 104.6613 | 103.9161 | 104.8269 | 103.6194 | 89.1430 | 81.0548 | 74.6419 | 72.3656 | 68.2086 | 66.3848 | 63.6946 |

**Standard Deviation of Hourly Averages**

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 25.3410 | 24.5628 | 23.9807 | 23.6660 | 23.9456 | 23.4802 | 24.9052 | 100.0932 | 141.2379 | 180.3954 | 183.4821 | 185.3354 | 193.8659 | 181.9761 | 178.2780 | 171.9746 | 165.1374 | 113.1544 | 90.6599 | 75.8714 | 65.3395 | 51.6266 | 32.7669 | 28.6587 |
| 1-B-S | 16.9846 | 16.0338 | 16.2044 | 15.9703 | 15.8685 | 15.2908 | 15.8143 | 43.3088 | 98.8716 | 147.7952 | 151.0817 | 154.3809 | 157.2386 | 146.0023 | 143.0841 | 141.9651 | 132.6919 | 80.9606 | 60.0906 | 51.3174 | 42.9628 | 32.4450 | 23.8272 | 18.7570 |
| 0-A-S | 5.0023 | 5.1525 | 6.9990 | 4.2755 | 4.3433 | 4.3066 | 9.7434 | 21.2865 | 65.4293 | 118.6169 | 127.6811 | 127.3434 | 128.2437 | 122.2285 | 118.2886 | 115.2279 | 108.9561 | 67.8297 | 57.0291 | 42.1453 | 35.4515 | 16.4755 | 8.2720 | 5.3669 |
| 0-B-S | 9.2759 | 7.0121 | 8.1867 | 7.2048 | 6.5885 | 8.3277 | 15.3085 | 41.2448 | 91.8113 | 141.4267 | 149.8942 | 148.7512 | 149.2720 | 140.5707 | 134.9211 | 134.3449 | 125.9359 | 73.0636 | 59.0526 | 49.0909 | 46.9723 | 37.5807 | 19.9797 | 13.8514 |
| 1-A-NS | 6.4345 | 5.4261 | 5.6430 | 5.5277 | 5.3563 | 10.3032 | 11.8481 | 30.9575 | 84.5955 | 138.5149 | 144.9874 | 145.8488 | 145.4274 | 137.6667 | 128.9166 | 129.3831 | 118.6730 | 74.1428 | 59.4598 | 47.1399 | 40.7147 | 29.4638 | 20.1145 | 13.1435 |
| 1-B-NS | 11.2263 | 9.8791 | 9.3756 | 9.0758 | 8.8135 | 9.1657 | 8.8091 | 36.8922 | 100.0480 | 142.8922 | 143.8453 | 146.9212 | 146.8342 | 138.4398 | 133.9863 | 134.4776 | 128.0702 | 78.4337 | 62.5079 | 48.5720 | 41.1901 | 33.8299 | 18.4692 | 12.5877 |
| 0-A-NS | 6.3878 | 3.0515 | 4.7082 | 4.3656 | 4.1897 | 5.0384 | 5.4141 | 19.7933 | 57.5177 | 73.9479 | 83.8130 | 89.9791 | 91.3395 | 85.2871 | 76.1813 | 70.7657 | 66.9877 | 47.0584 | 31.2224 | 19.0053 | 16.2480 | 16.0963 | 11.3177 | 5.8065 |
| 0-B-NS | 12.0600 | 15.1783 | 14.4982 | 11.7996 | 11.1014 | 10.8808 | 13.4575 | 45.7692 | 102.3336 | 136.4169 | 143.2010 | 142.8401 | 141.8253 | 133.9656 | 132.5129 | 134.7850 | 131.6408 | 81.7059 | 70.6250 | 50.0812 | 39.3718 | 29.7149 | 15.3570 | 10.8284 |

**Count of Data Points**

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |
| 1-B-S | 394 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 394 | 395 | 395 | 395 | 395 | 395 | 395 | 395 |
| 0-A-S | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| 0-B-S | 226 | 225 | 226 | 226 | 226 | 226 | 226 | 226 | 226 | 225 | 224 | 225 | 225 | 225 | 226 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 |
| 1-A-NS | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 75 | 74 | 75 | 75 | 75 | 76 | 77 | 77 | 77 | 77 | 77 | 77 | 77 | 77 | 77 |
| 1-B-NS | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 |
| 0-A-NS | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 |
| 0-B-NS | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 92 | 93 |

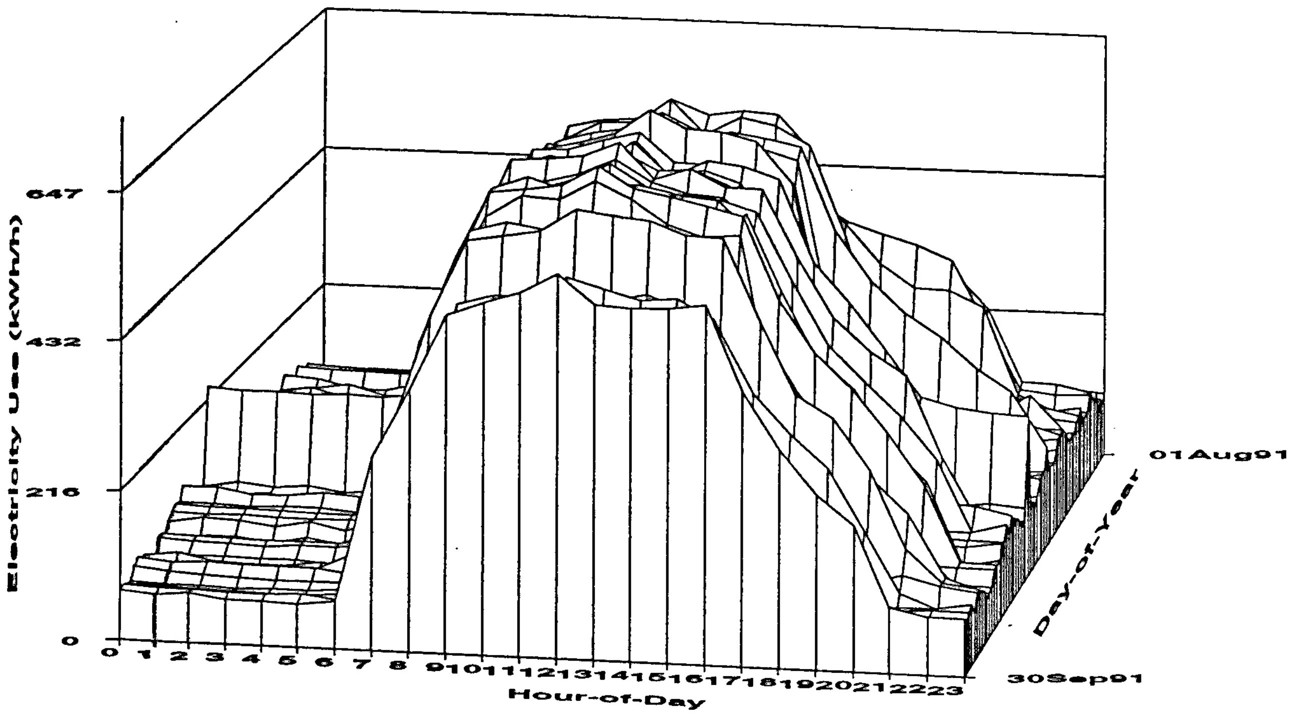
**Key**

| | | |
|---|---|---|
| 1-A-S | = | Semester/Weekday/Pre-Retrofit |
| 1-B-S | = | Semester/Weekday/Post-Retrofit |
| 0-A-S | = | Semester/Weekend/Pre-Retrofit |
| 0-B-S | = | Semester/Weekend/Post-Retrofit |
| 1-A-NS | = | Non-Semester/Weekday/Pre-Retrofit |
| 1-B-NS | = | Non-Semester/Weekday/Post-Retrofit |
| 0-A-NS | = | Non-Semester/Weekend/Pre-Retrofit |
| 0-B-NS | = | Non-Semester/Weekend/Post-Retrofit |

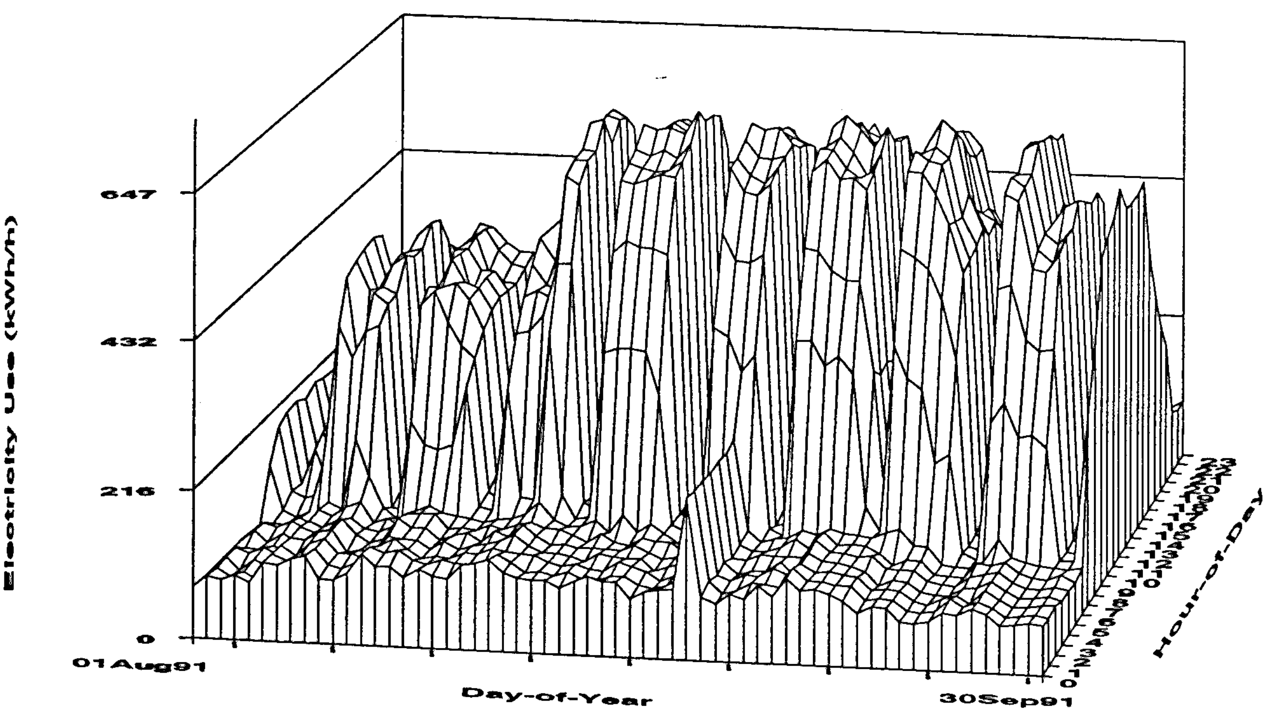
## Tab A-5

## MECR Plots

Whole–Building Electric



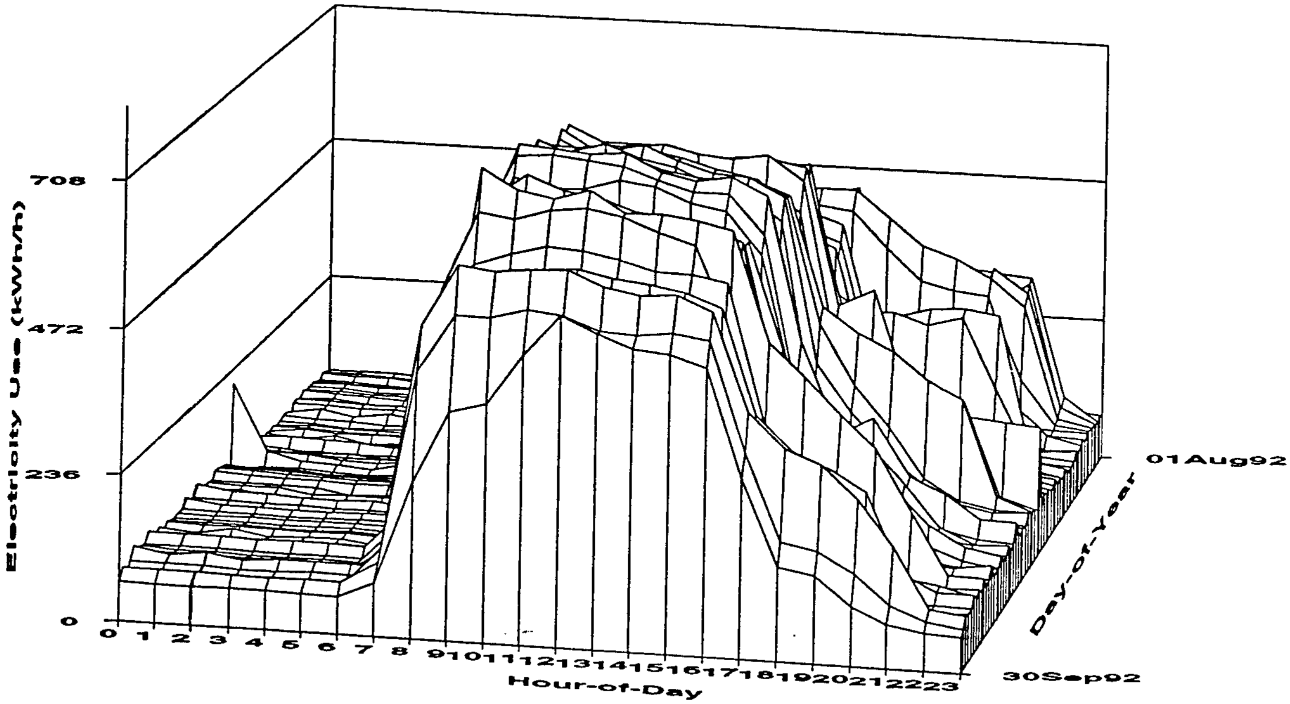

Whole–Building Electric



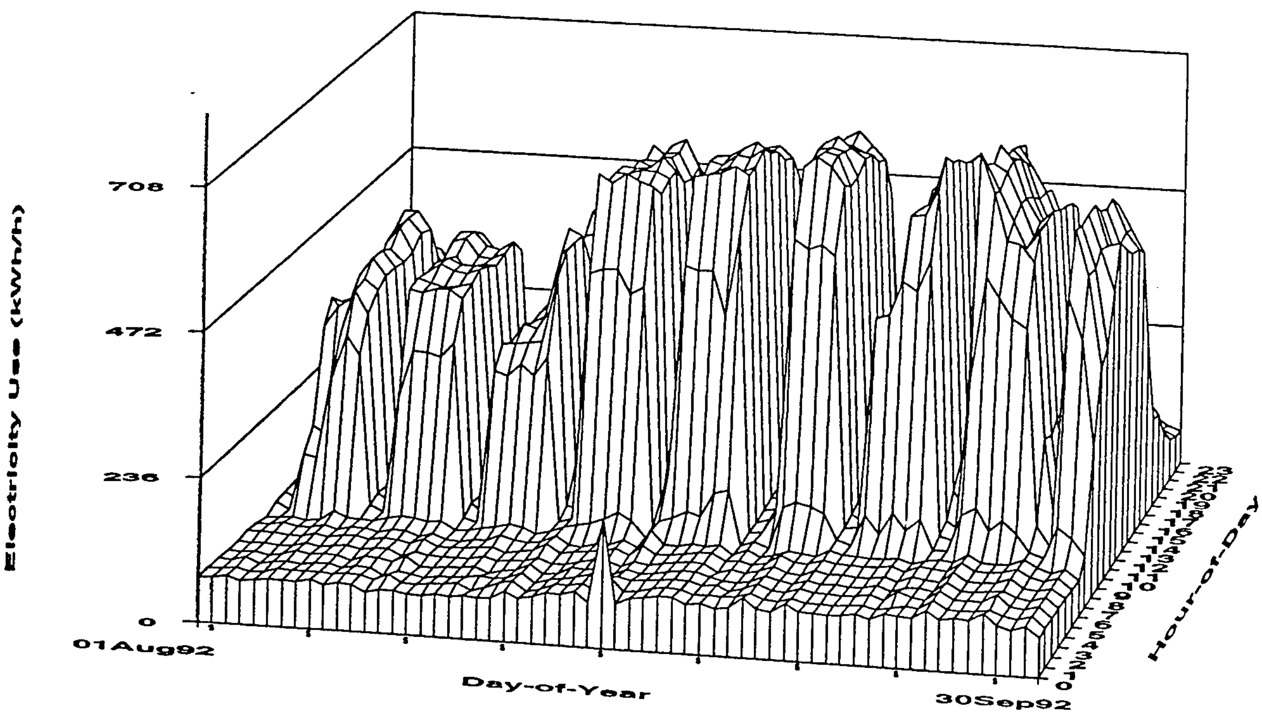

Sundays are marked with an "S"

Stroman High School - Victoria ISD - September 1991

Whole-Building Electric



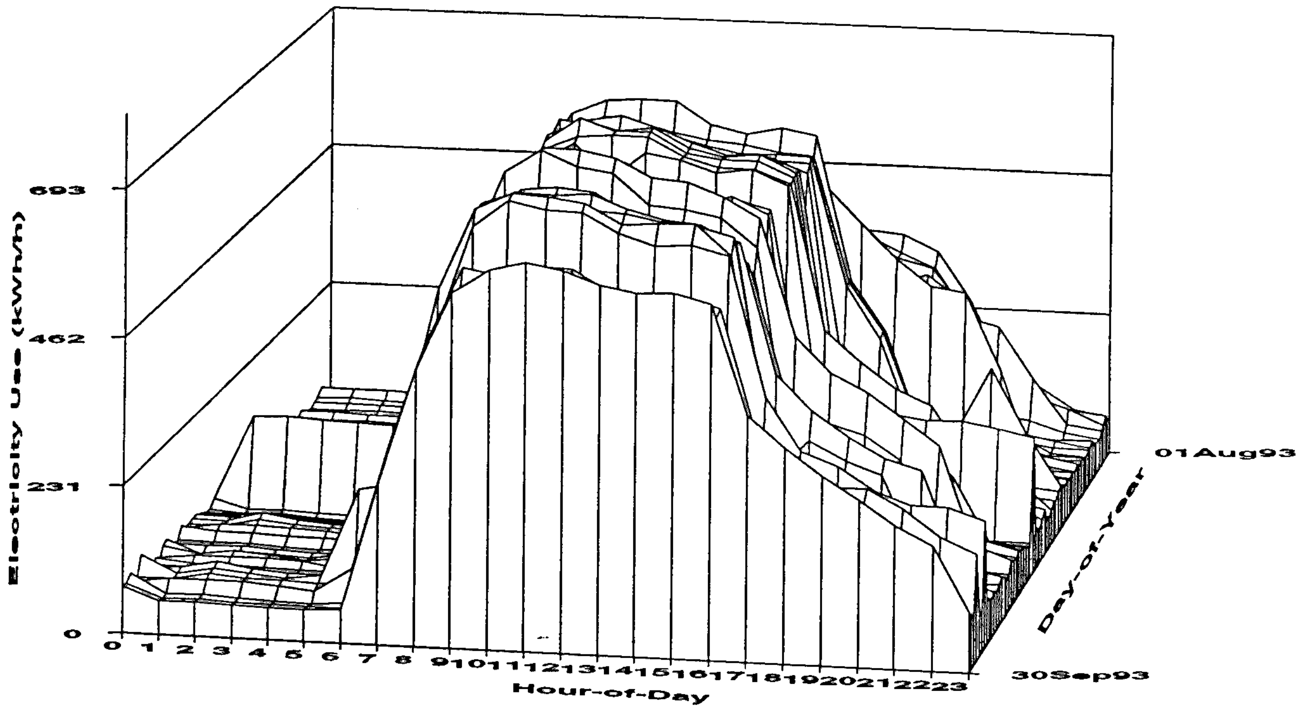

Whole-Building Electric



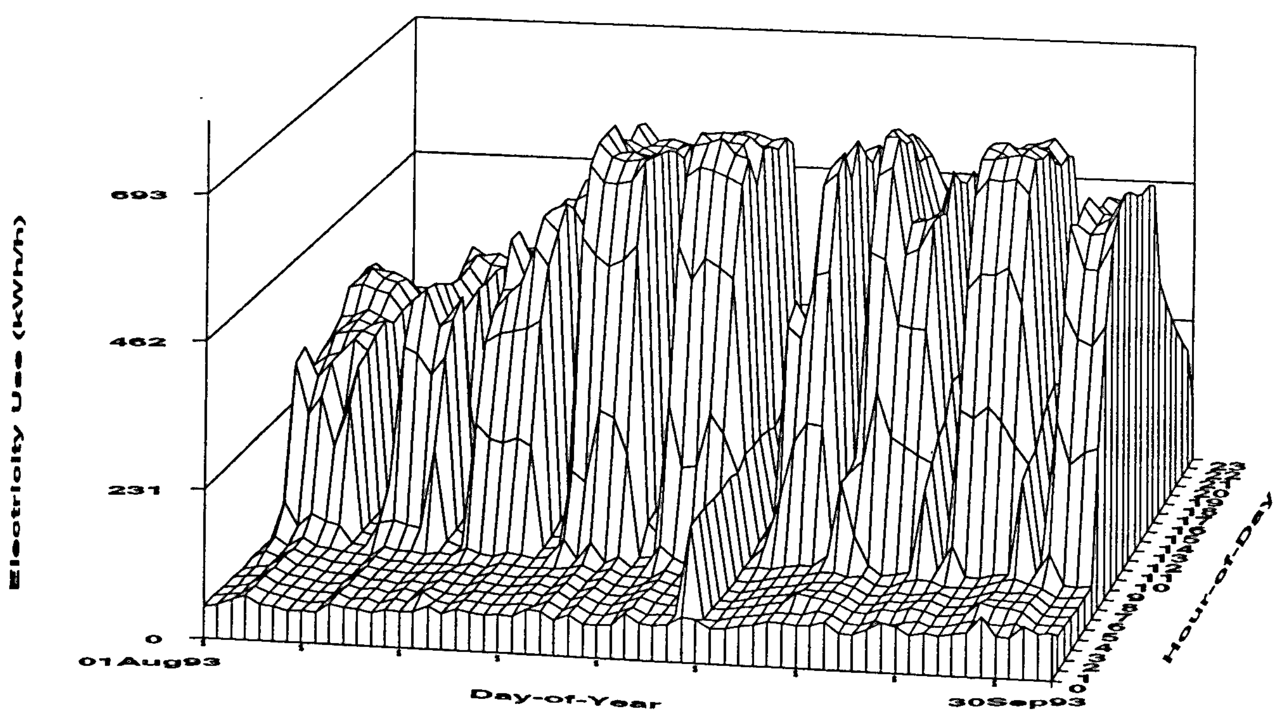

Sundays are marked with an "S"

Stroman High School - Victoria ISD - September 1992

## Whole–Building Electric



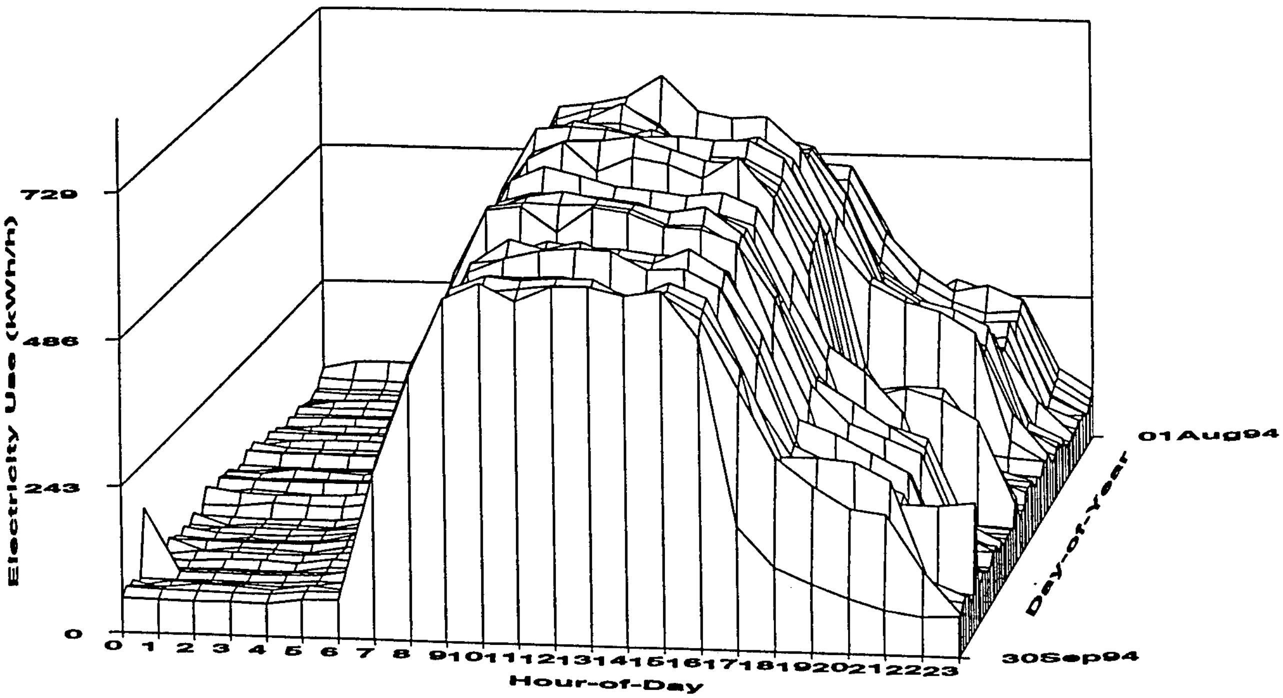

## Whole–Building Electric



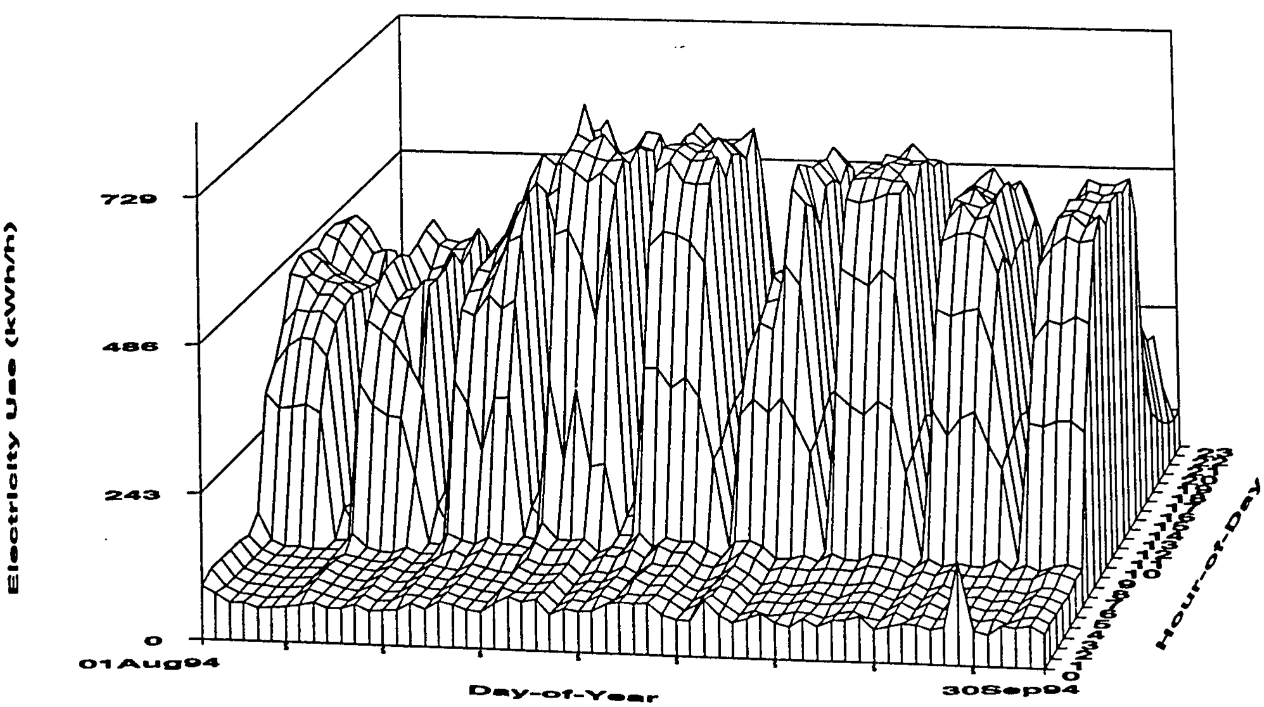

Sundays are marked with an "S"

Stroman High School - Victoria ISD - September 1993

## Whole–Building Electric




## Whole–Building Electric




Sundays are marked with an "S"

Stroman High School - Victoria ISD - September 1994

# TAB A-6

## Data Summary Notebook Information

# VICTORIA INDEPENDENT SCHOOL DISTRICT

## Stroman High School

**Building Envelope:**
- 210,500 sq.ft.
- Unit A: four storied, administrative offices on ground floor, classrooms on 2nd and 4th floors, 17,500 sq ft/floor.
- Unit B: 2 storied, auditorium, choir room, band room, and drafting classroom, 12,000 sq ft/floor.
- Unit C: single story, cafeteria and kitchen, 9,000 sq ft.
- Unit D and E: One contiguous building, 2 storied, library, gymnasium, locker rooms, and main mechanical room, 25,000 sq ft (Unit D), 27,000 sq ft (Unit E).
- Unit F: 2 storied, science classrooms, 23,000 sq ft.
- Unit G: single storied, shops, 7,000 sq ft.
- 3 Athletic Buildings: girls' gym, field house, and athletic dome, 25,000 sq ft.

**Building Schedule:**
- 7 am to 4 pm (M-F)

**Building HVAC and Other Equipment:**
- Unit A: 4 AHUs (1 mutizone of 7.5hp and 3 single zone of 3hp each), 50 fan-coil units and 1-45.8 ton chiller
- Unit B: 1 single zone AHU of 3hp and a rooftop DX unit
- Unit C: 2 single zone units of 0.75 hp each and 6 fan-coil units
- Unit D and E: 3 AHUs, 1 single zone of 5hp 2 H&V units of 2 hp each. and 2 fan-coil units
- Unit F: 18 fan-coil units
- Unit G: 2 rooftop DX units
- 18 exhaust fans (1/4 hp each)

**HVAC Schedule:**
- HVAC equipment is turned on manually at 7:00a.m. and turned off at 8:00p.m., on weekdays.

**Auxillary Equipment:**
- 3 single zone AHUs. @ of 3 hp each, 1 of 0.75hp.
- 1 - 50 hp chilled water pump.
- 1 - 20 hp hot water pump.
- 1 - 30 hp cooling tower.
- 1 - 2 hp boiler motor.
- 1 brine pump.
- 1 refrigerant pump.
- 1 reciprocating chiller of 3 hp.
- 2 gas fired boilers.
- 1 rooftop unit serving the First Aid room.
- 1 centrifugal chiller @ 460 tons (replaced 414 ton absorption chiller in Aug 91).
- 3 hot water heaters (500,000 Btu/hr each).

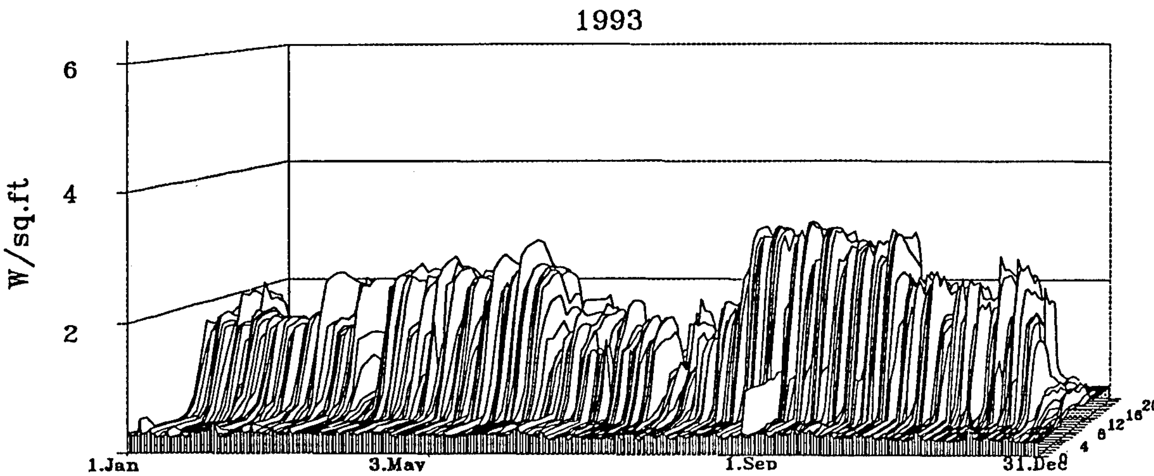
**Lighting:**
- mostly fluorescent (40 W). Total lighting load 260 kW.

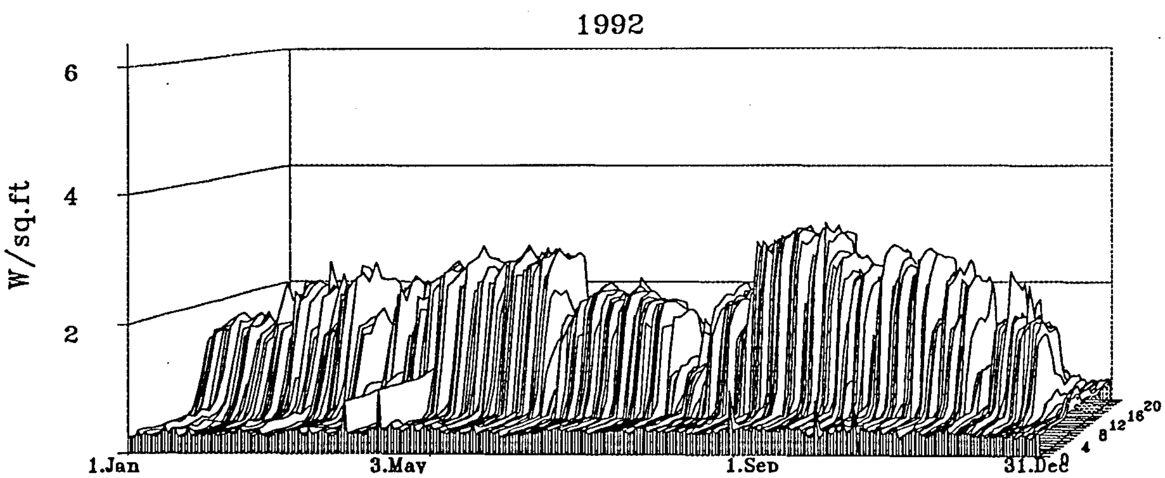
**Proposed Retrofits:**
- Energy Management System.
- replace absorption chiller.
- rewire wiring in hallways.

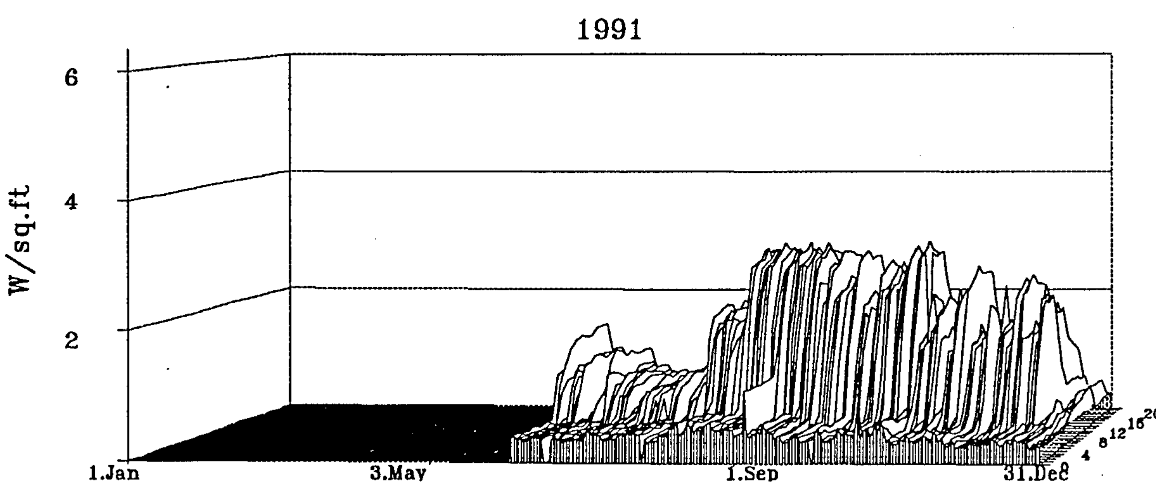
**Date of Retrofits:**

- replacement of absorption chiller was completed in August 1991. Work on the other two retrofits was completed in January 1992.

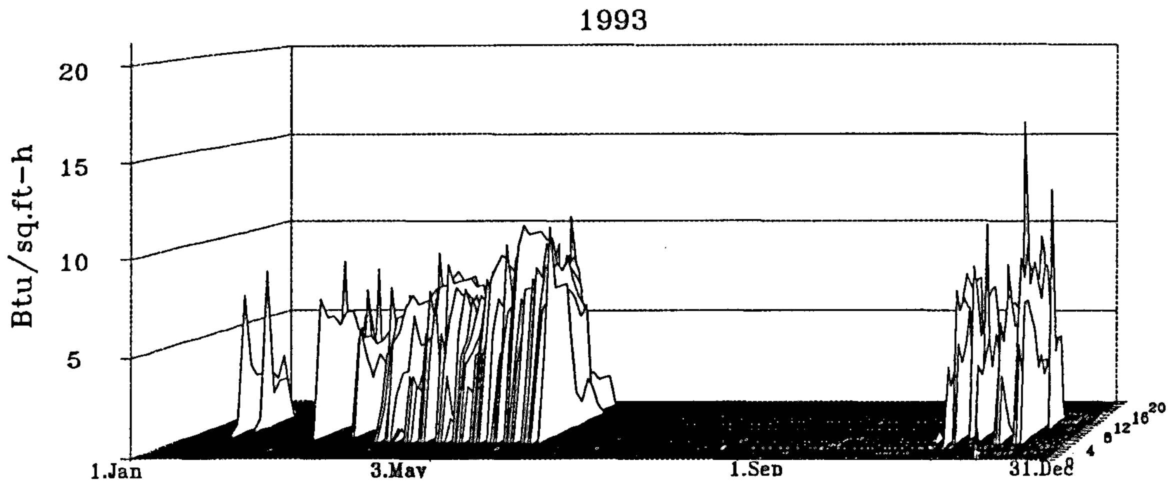
# Stroman High School (SHS)
# W.B. Electric as W/sq.ft.

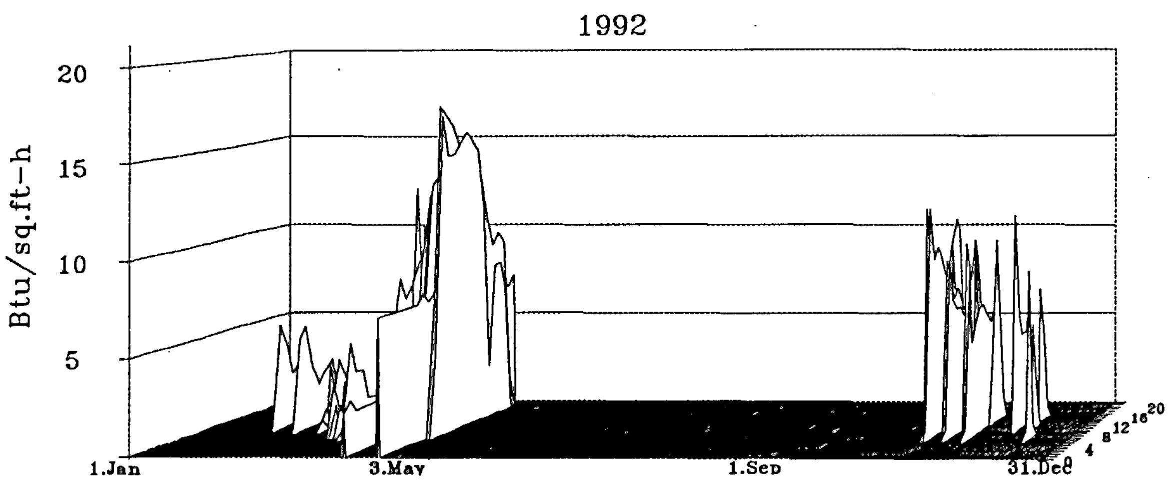


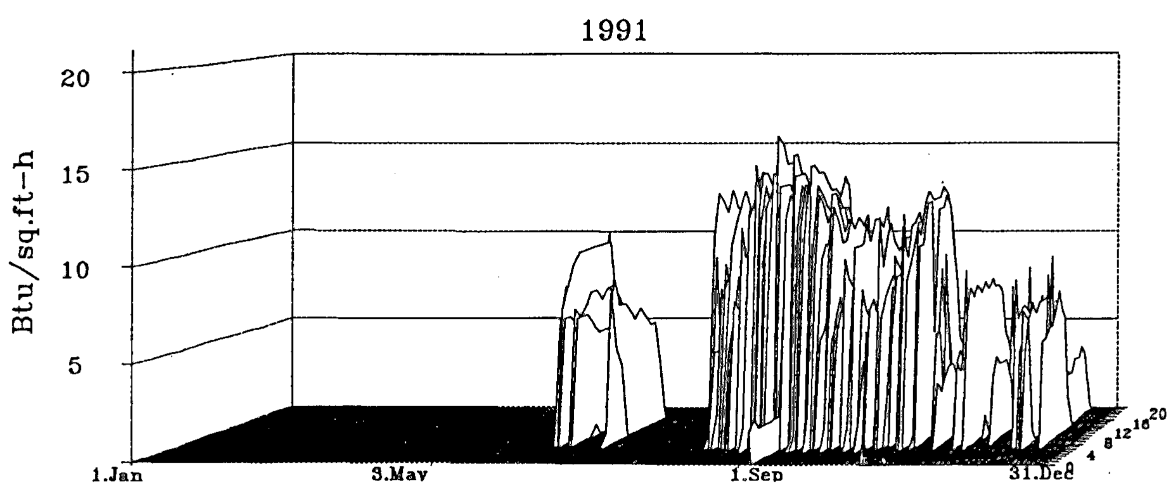



# Stroman High School (SHS)
# W.B. CHW as Btu/sq.ft.-h

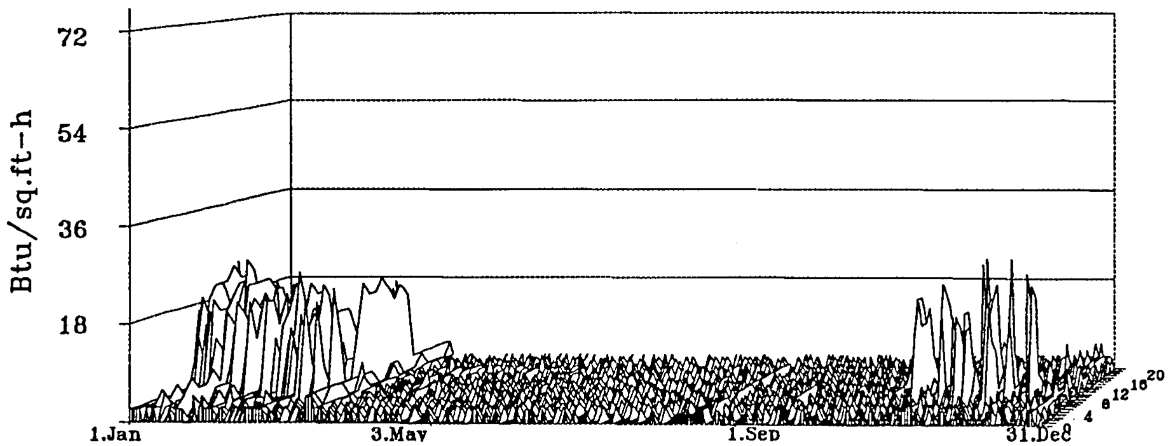


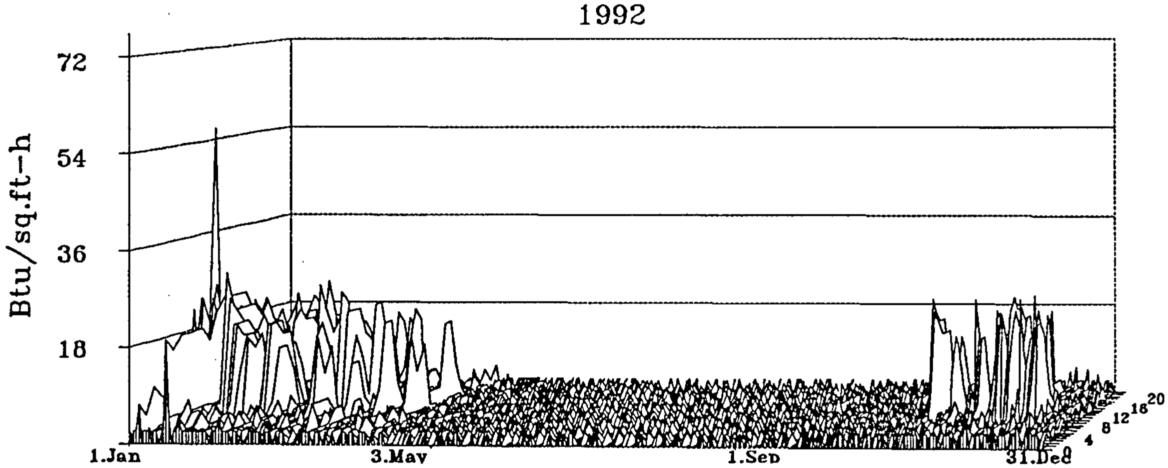



# Stroman High School (SHS)
# W.B. HW as Btu/sq.ft.-h

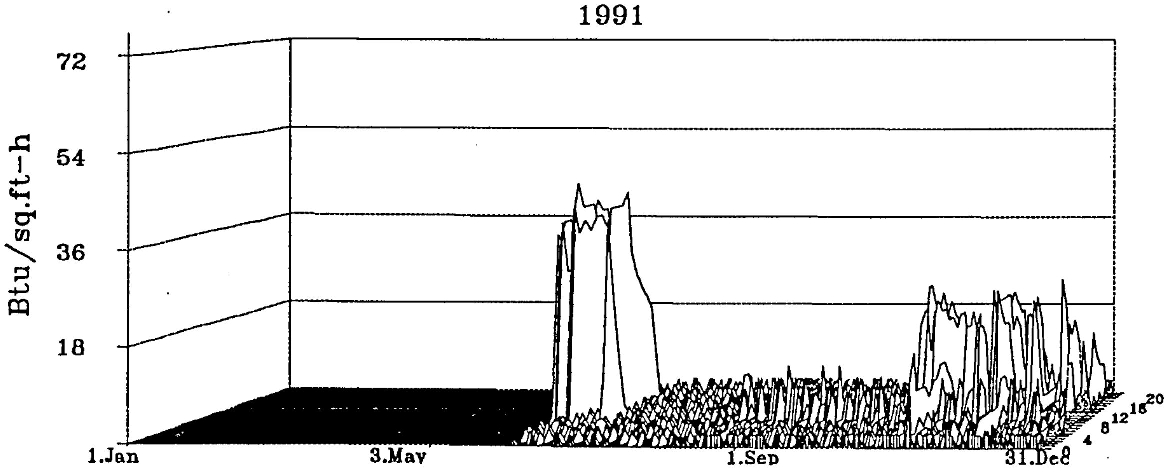
1993



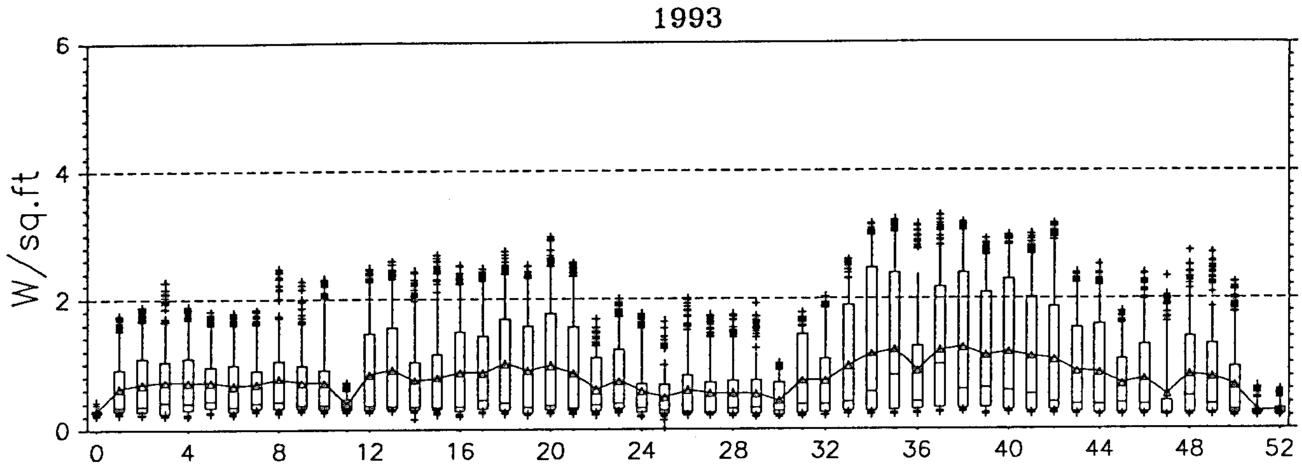

1992

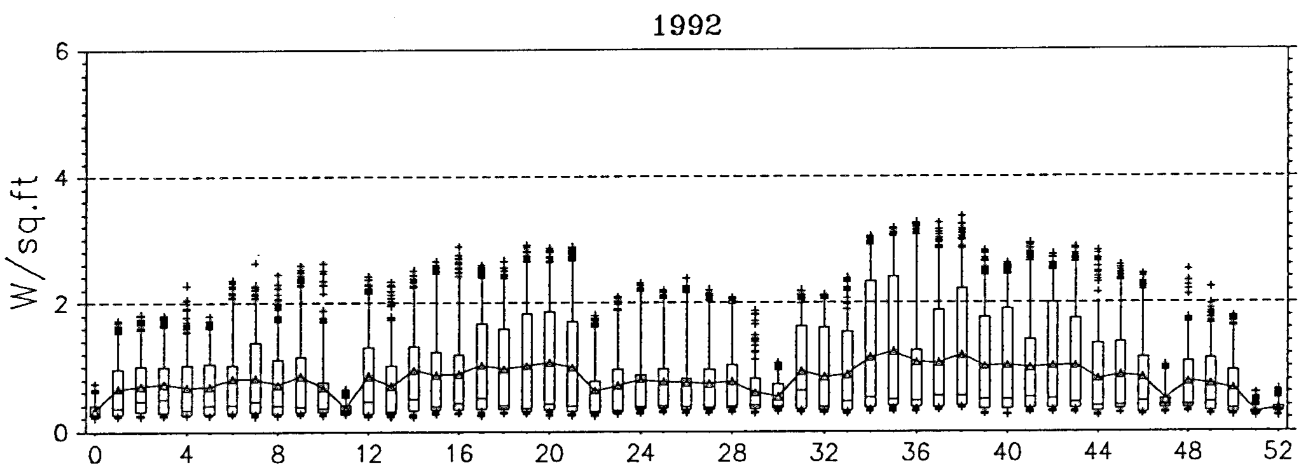


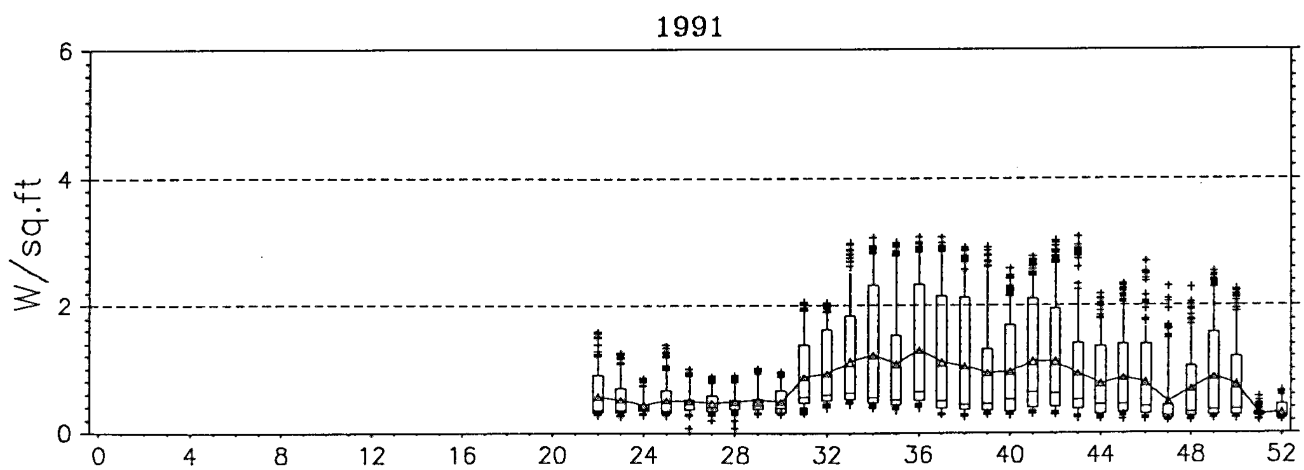

1991



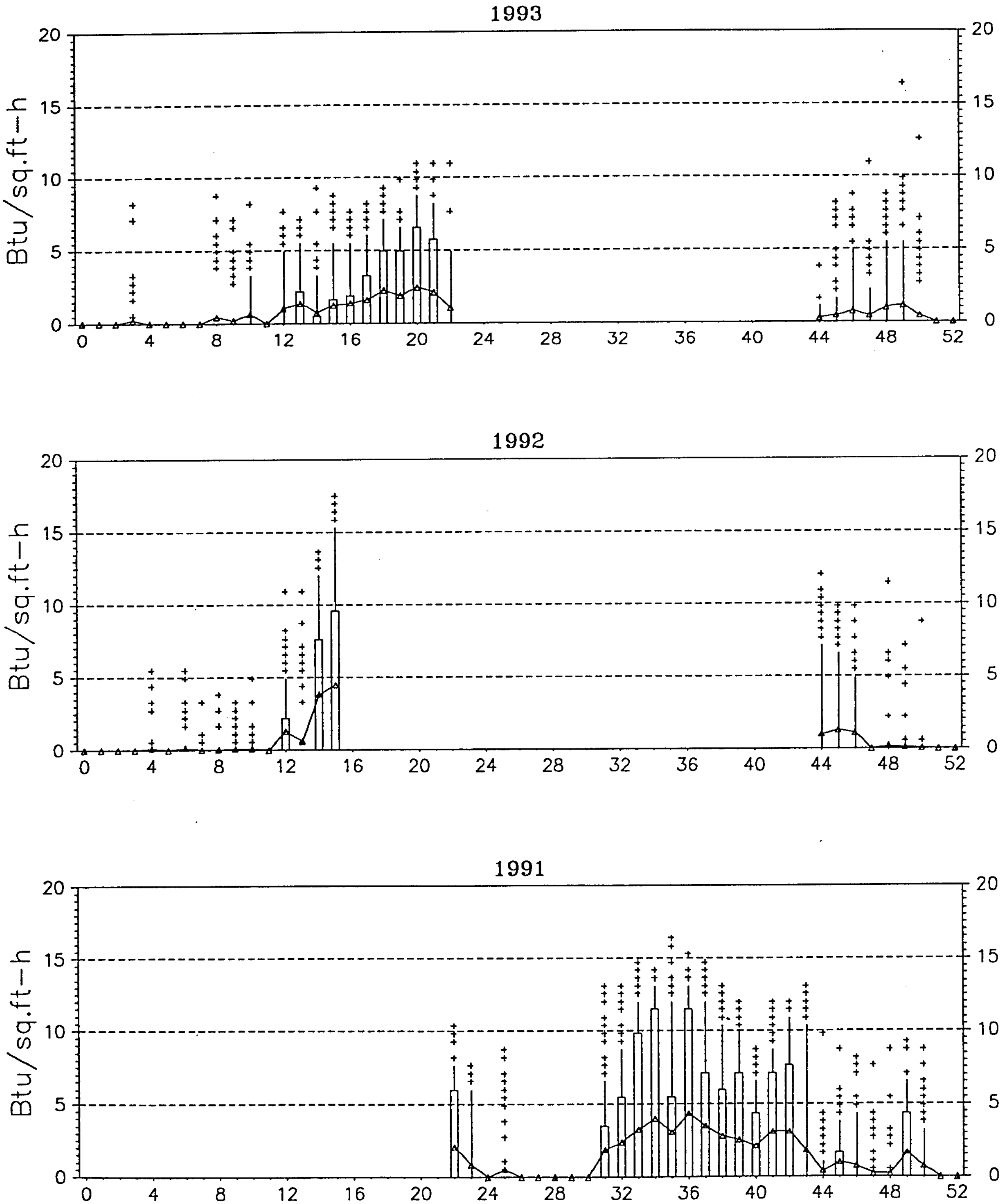
# Stroman High School (SHS)
# W.B. Electric as W/sq.ft.



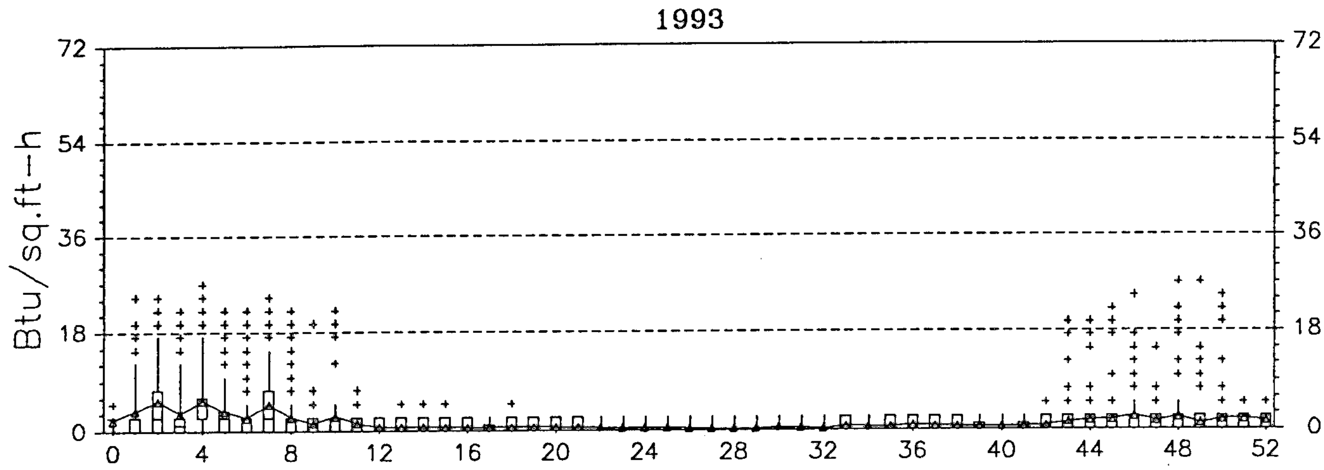



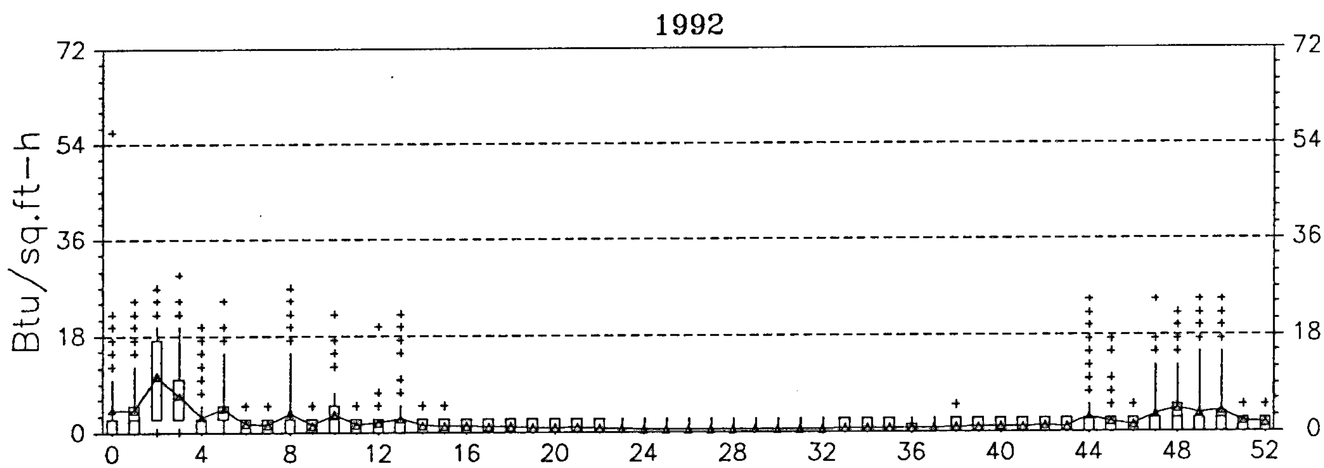



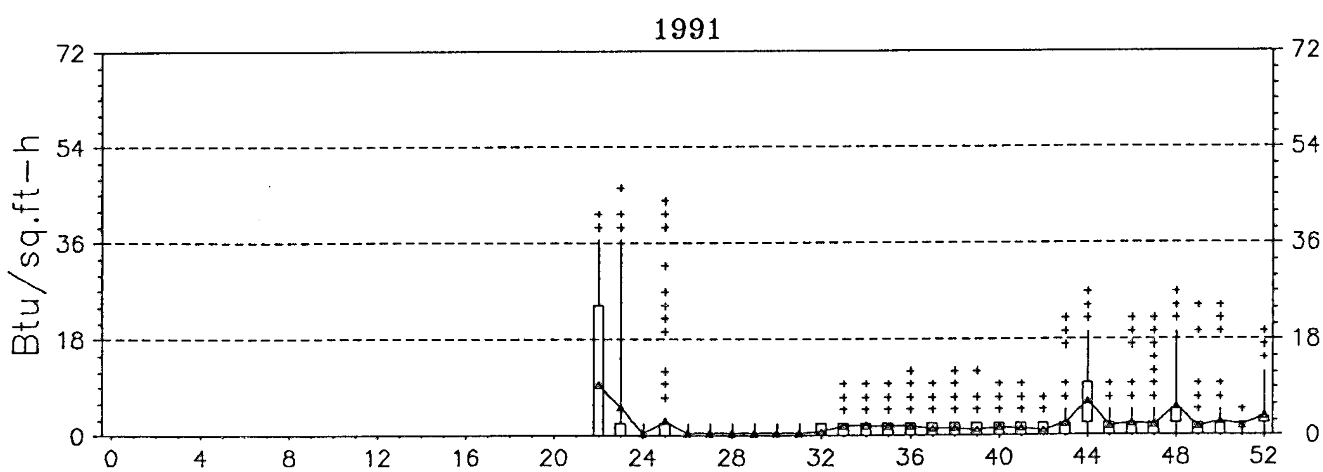
# Stroman High School (SHS)
# W.B. CHW as Btu/sq.ft.-h



# Stroman High School (SHS)
# W.B. HW as Btu/sq.ft.-h



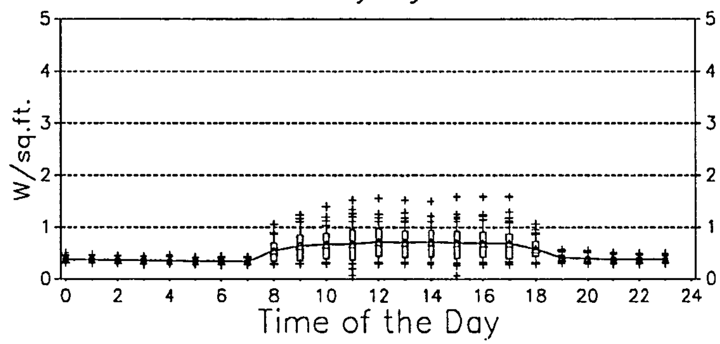



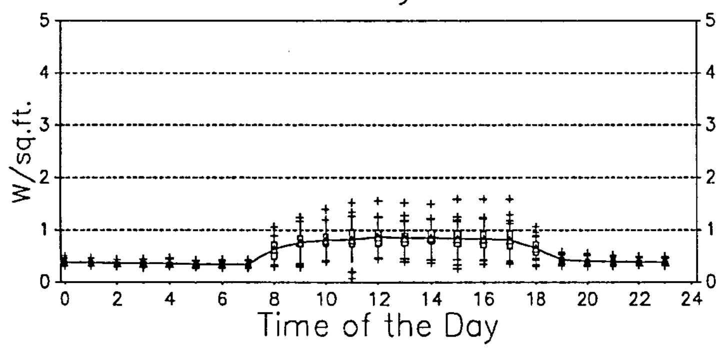
# Stroman High School (SHS)
# W.B. Electric as W/sq.ft.

## Pre-Retrofit (06/04/1991 - 08/01/1991)

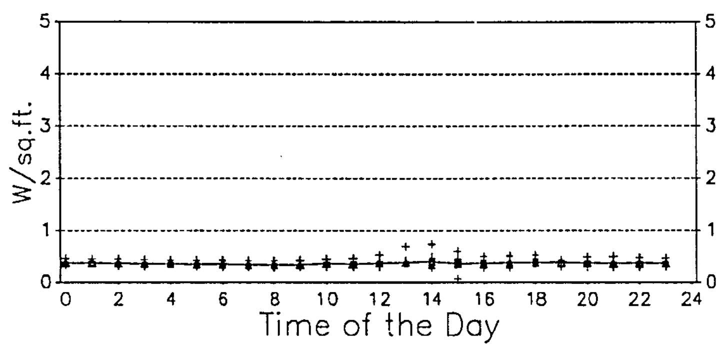
Everyday




Weekdays

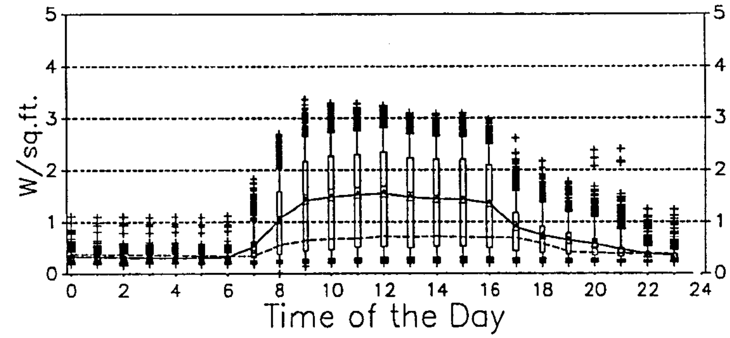



Weekends

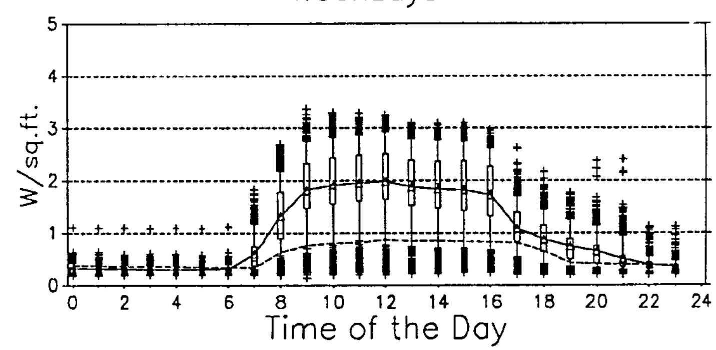



## Post-Retrofit (08/15/1991 - 12/31/1993)

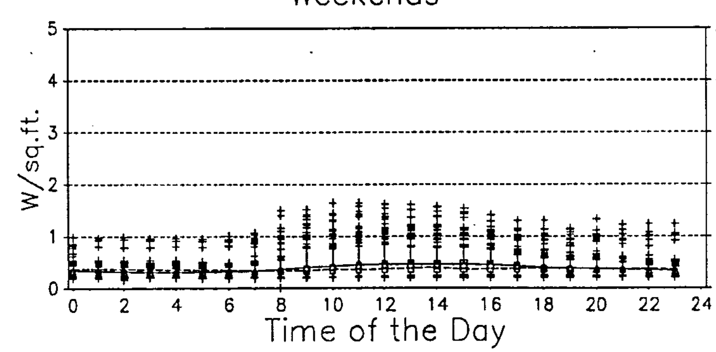
Everyday




Weekdays

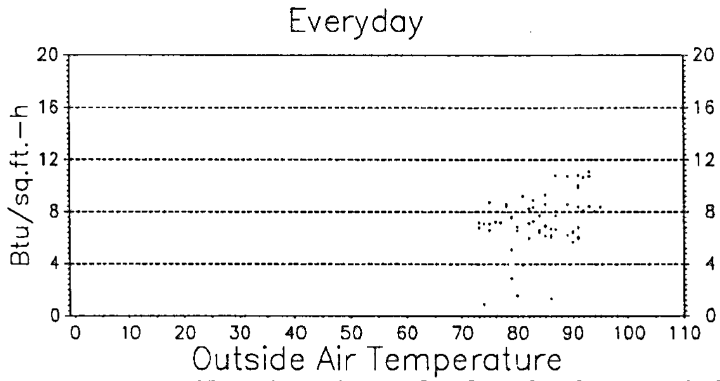



Weekends

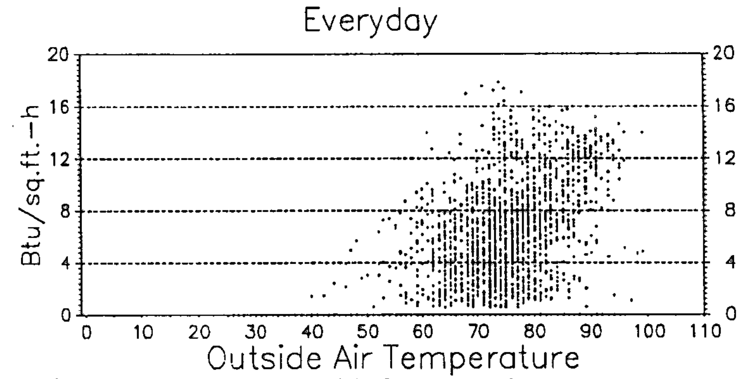


# Stroman High School (SHS)
# W.B. CHW as Btu/sq.ft.-h

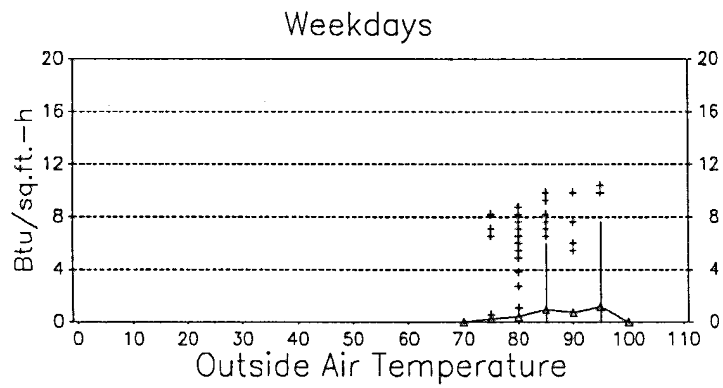
## Pre-Retrofit (06/04/1991 - 08/01/1991)

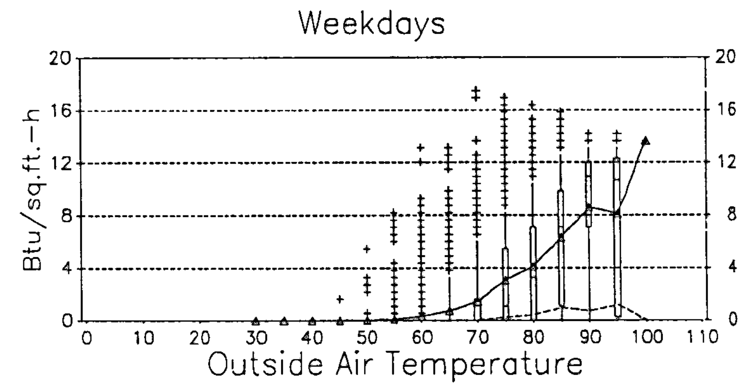


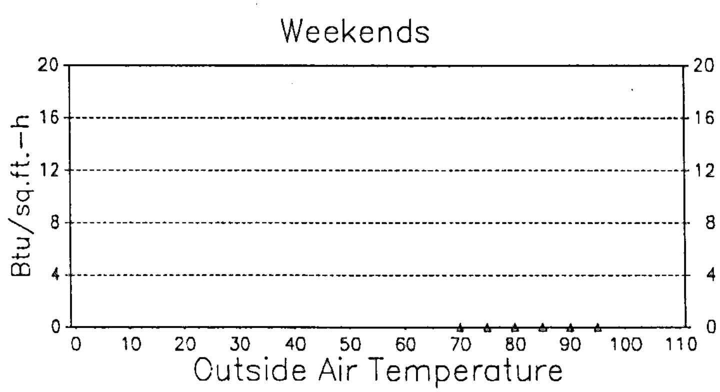

## Post-Retrofit (08/15/1991 - 12/31/1993)

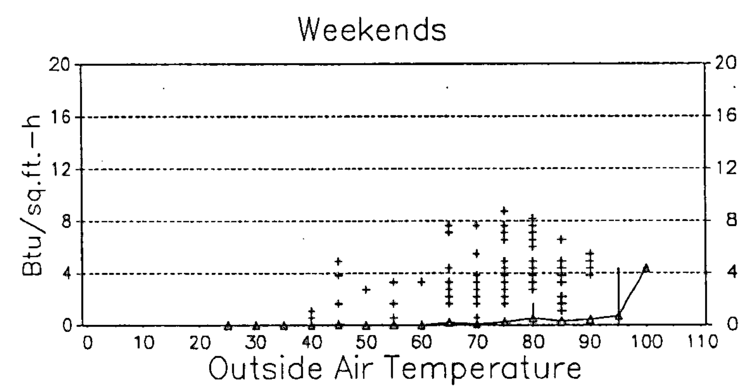



**Note: Data in graphs above has been vertically offset randomly up to 1 Btu/sq.ft.-h to improve graphical presentation.**



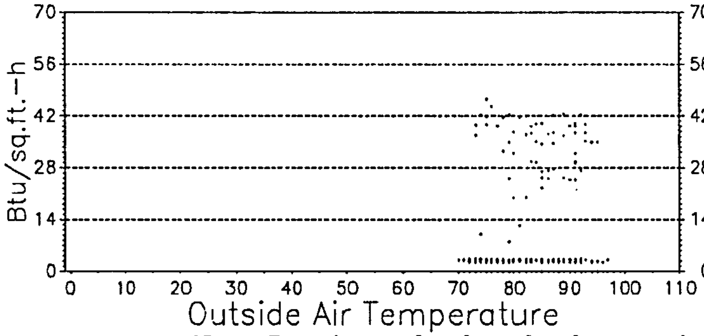



# Stroman High School (SHS)
# W.B. HW as Btu/sq.ft.-h

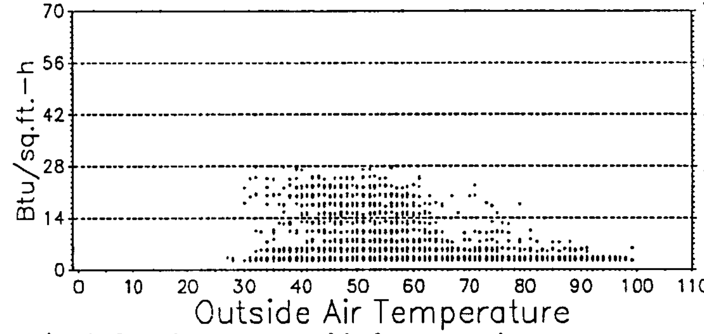
## Pre-Retrofit (06/04/1991 - 08/01/1991)

### Everyday



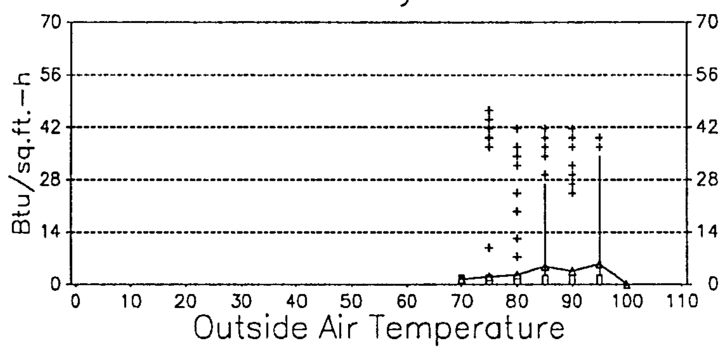

## Post-Retrofit (08/15/1991 - 12/31/1993)

### Everyday

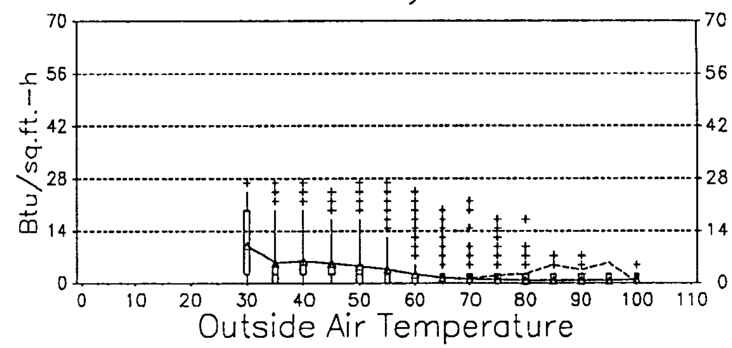



**Note: Data in graphs above has been vertically offset randomly up to 1 Btu/sq.ft.-h to improve graphical presentation.**

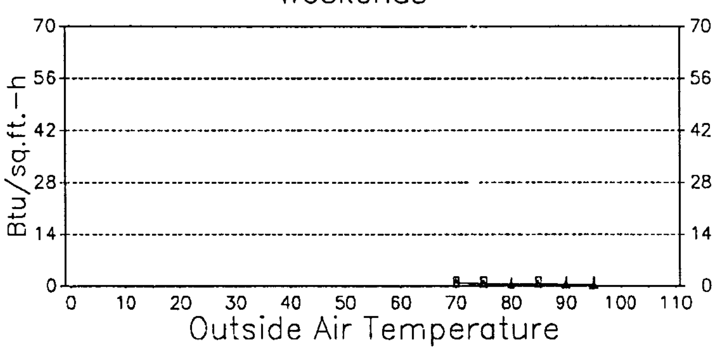
### Weekdays



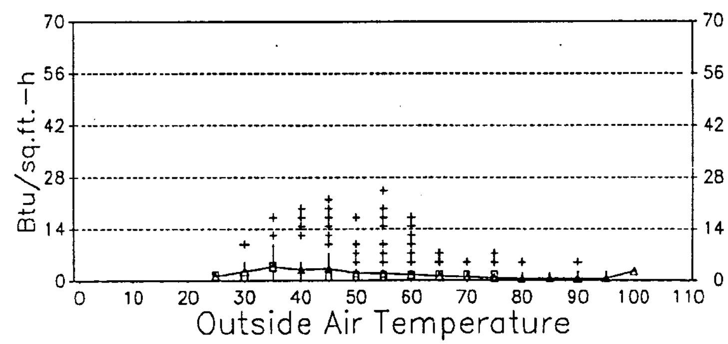

### Weekdays




### Weekends

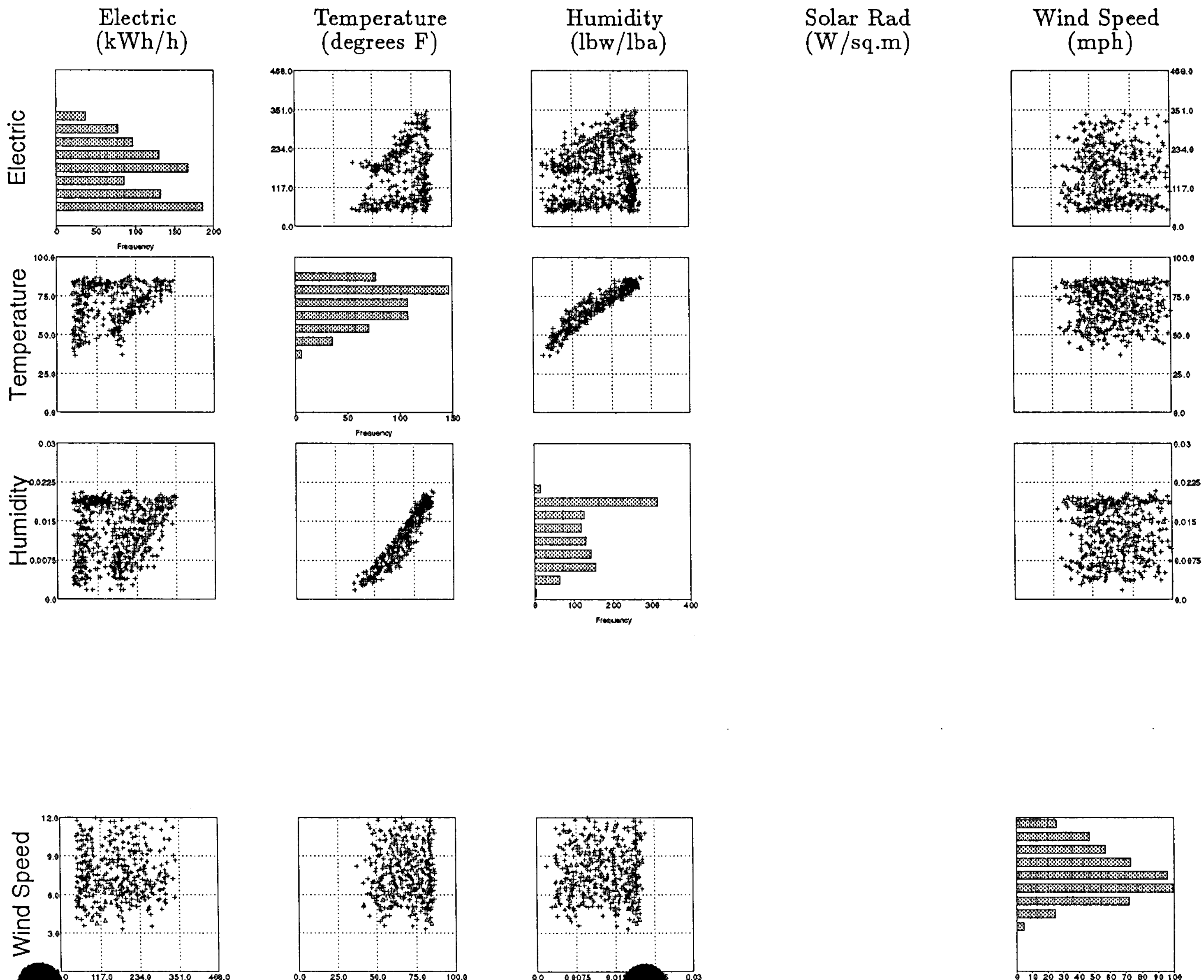



### Weekends



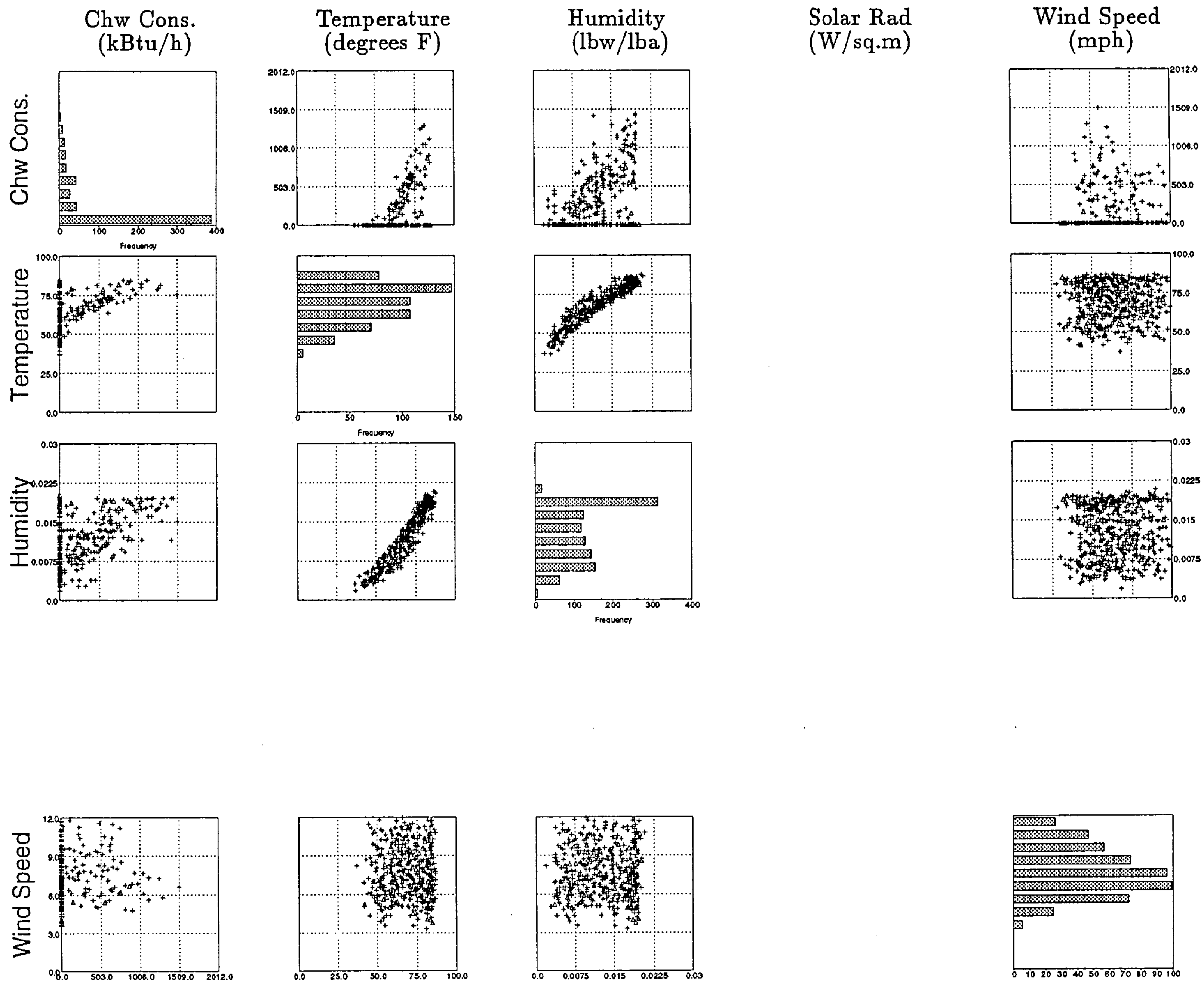
# Stroman High School (SHS)
# Daily Average Values

Pre-Retrofit (△) 06/04/1991 - 08/01/1991 Post-Retrofit (+) 08/15/1991 - 12/31/1993



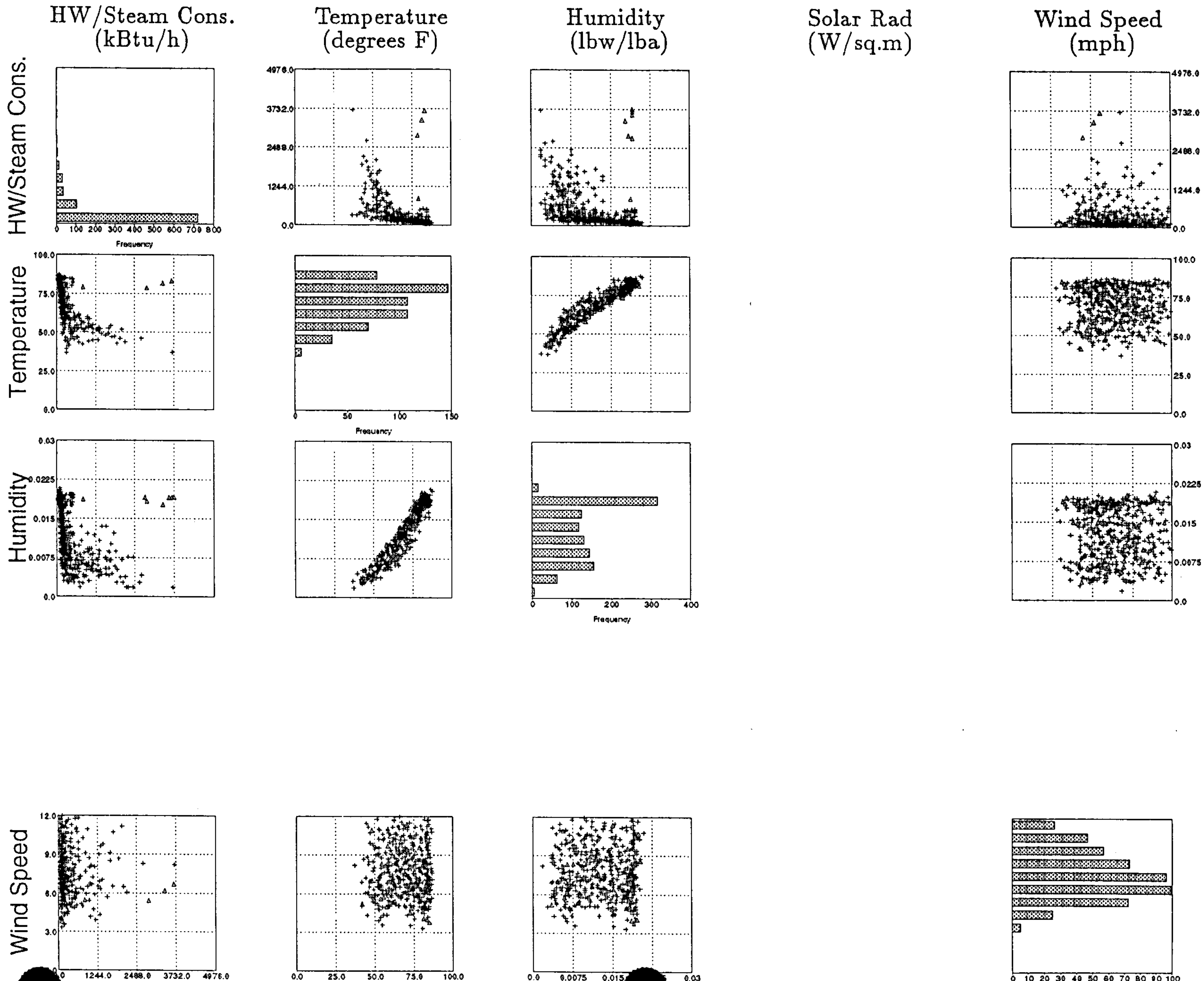
# Stroman High School (SHS)
## Daily Average Values

Pre-Retrofit (△) 06/04/1991 - 08/01/1991 Post-Retrofit (+) 08/15/1991 - 12/31/1993



# Stroman High School (SHS)
## Daily Average Values

Pre-Retrofit (△) 06/04/1991 - 08/01/1991 Post-Retrofit (+) 08/15/1991 - 12/31/1993



# B. VICTORIA HIGH SCHOOL

## *B.1 Site Description*[1]

Victoria High School is located in Victoria, Texas. It consists of ten buildings with a total floor area of 257,014 square feet. The two largest buildings are the Main Building and the Academic Wing. Both of these buildings are two-story, brick, slab on grade, with flat roofs. Both buildings are served by hydronic fan-coil units. The chiller serving the Main Building is a 192 ton centrifugal chiller, with 25 horsepower chilled water and condenser pumps, and a 15 horsepower cooling tower fan. The chiller serving the Academic Wing is a 182 ton chiller with a 20 horsepower chilled water pump, a 15 horsepower condenser water pump, and a 20 horsepower cooling tower fan. The eight remaining buildings are all single story, served by rooftop units with direct expansion cooling and gas heating. These buildings include a field house/dressing room, two shop buildings, a gymnasium, special education building, learning resource center, home economics building, and a multipurpose building with kitchen, cafeteria, band hall, and choir rooms.

Air distribution is primarily through single duct air handling systems, providing cooling temperatures of approximately 75 °F, and heating temperatures within the range of 70 to 72 °F. Heating and air handling systems are turned off completely during the night and are controlled from a central location through a Carrier EMCS.

The school is operated from the middle of August through the middle of May, with approximately 2,135 students and 228 faculty and staff. The maximum school occupancy is from about 8:00 a.m. until 4:00 p.m.; however, the building is occupied for much longer periods, including weekends and summers. Stroman and Victoria High School alternate as the primary location for summer school. Victoria was the site during the summer of 1992. School district calendars for the reporting period of June 5, 1991, through June 4, 1994, are included in Tab B-1.

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[1] Adapted from: Landman, D.S., 1995. "Preliminary Study of Advanced Diagnostic Prescreening Methods," Energy Systems Laboratory, Mechanical Engineering Department, Texas A&M University, College Station, TX.

Electricity is purchased from Central Power and Light Company. Natural gas is purchased from ENTEX Gas Company.

## B.2 EMCS Retrofit

The energy audit for Victoria High School determined that the HVAC operation was controlled manually, which resulted in excessive operating hours in each of the schools in the school district. Timeclock controls were installed many years ago, but were not suited for the needs of the school. See Tab B-2 for the full text technical analysis of the facility, which was provided in the audit.

The proposed EMCS retrofit called for the installation of a direct digital control-based EMCS, which would control all HVAC equipment, measure exterior and interior space temperatures, and measure humidity in one or two critical locations within the school. The EMCS would have no override timers that custodial staffs could activate. Operating hours of all HVAC units would be determined by the maintenance staff, and controlled by that staff from its central headquarters via modem.

The EMCS system was installed and activated on January 31, 1992. It controls the HVAC equipment and some lights, and measures the temperature and humidity at select locations. Although there are override capabilities, they are not used.

## B.3 Analysis

### B.3.1 Snapshot of consumption for September 1991 through December 1993

Figures B-1 and B-2 represent monthly average consumption and peak consumption versus min-max average (or peak) monthly temperature.[2] Min-max average monthly temperature is calculated by averaging the maximum and minimum temperature each day to obtain min-max average daily temperature. The daily temperatures are then averaged over all days in each month to obtain min-max average monthly temperature.

[2] Landman, D.S., 1995. "Preliminary Study of Advanced Diagnostic Prescreening Methods," Energy Systems Laboratory, Mechanical Engineering Department, Texas A&M University, College Station, TX.

The data points reflecting high temperature and low consumption are indicative of non-semester consumption. If those data points are ignored, there is a general increase of consumption with temperature, indicating a temperature dependence of consumption. Additionally, the post-retrofit data points are generally lower than the pre-retrofit data points. When compared to similar plots for other Texas schools in the LoanSTAR program, this site is a low energy use school. However, it does have higher energy use than Stroman High School. The reader is referred to the referenced report for a more detailed discussion of these plots.

**Figure B-1:** ***Monthly Average Consumption:*** **Consumption, in W/sf, versus min-max average monthly temperature, in °F, for September 1991 through December 1993 (Victoria High School)**

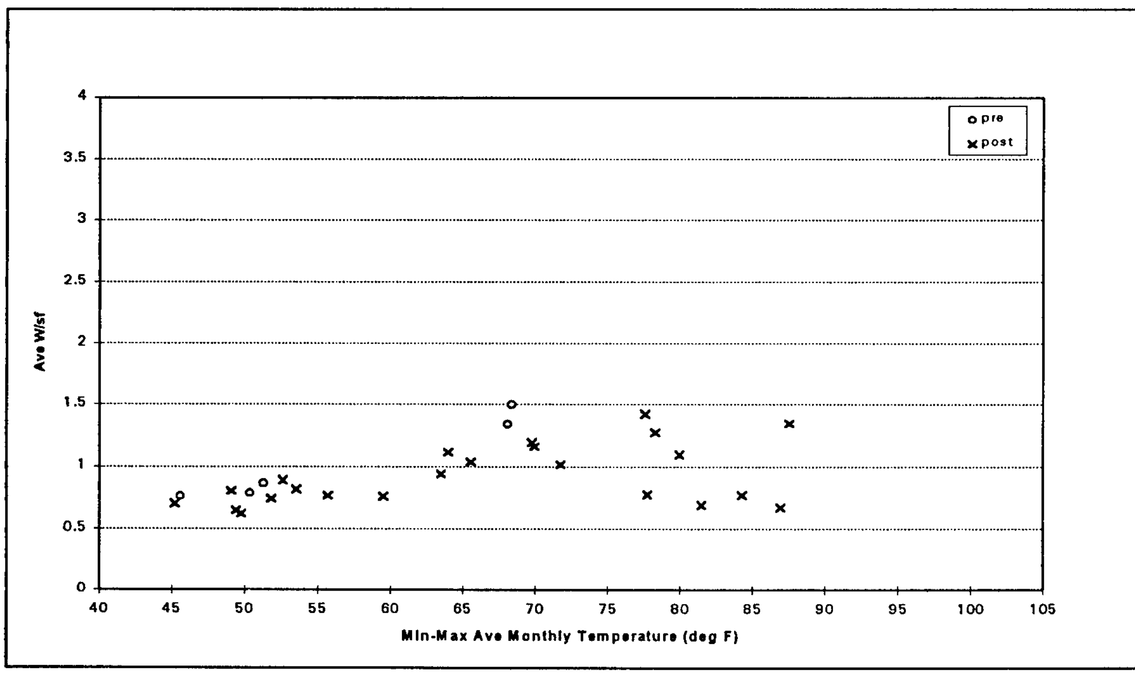
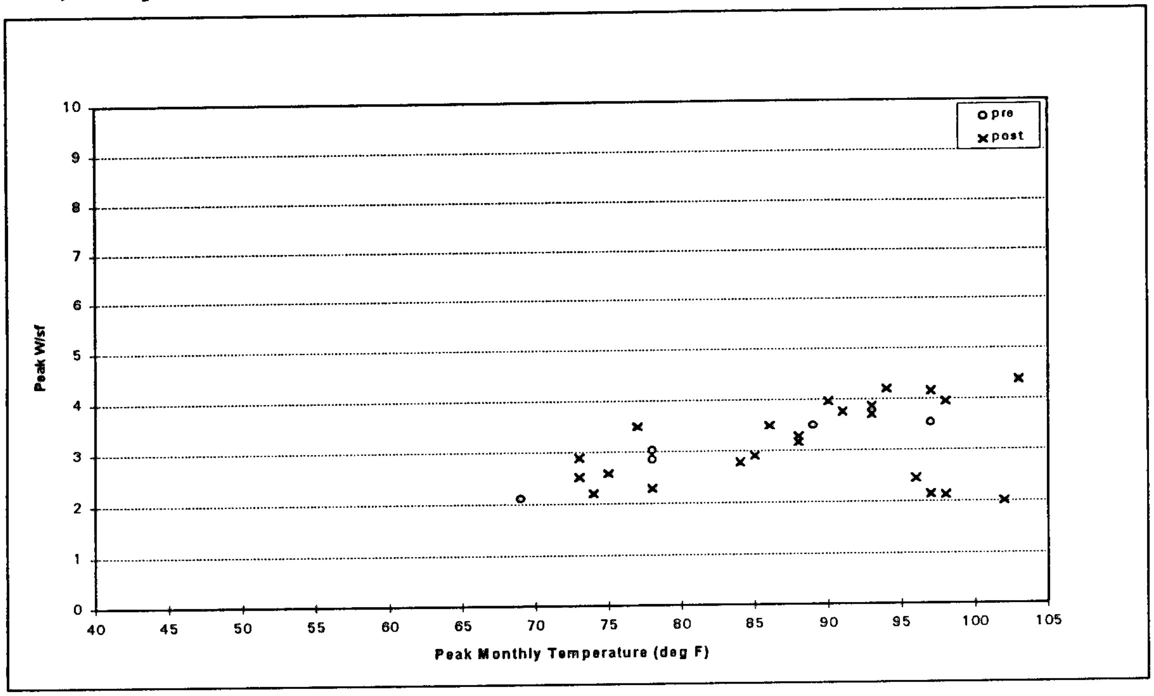


Figure B-2: *Monthly Peak Consumption:* **Consumption, in W/sf, versus peak monthly temperature, in °F, for September 1991 through December 1993 (Victoria High School)**



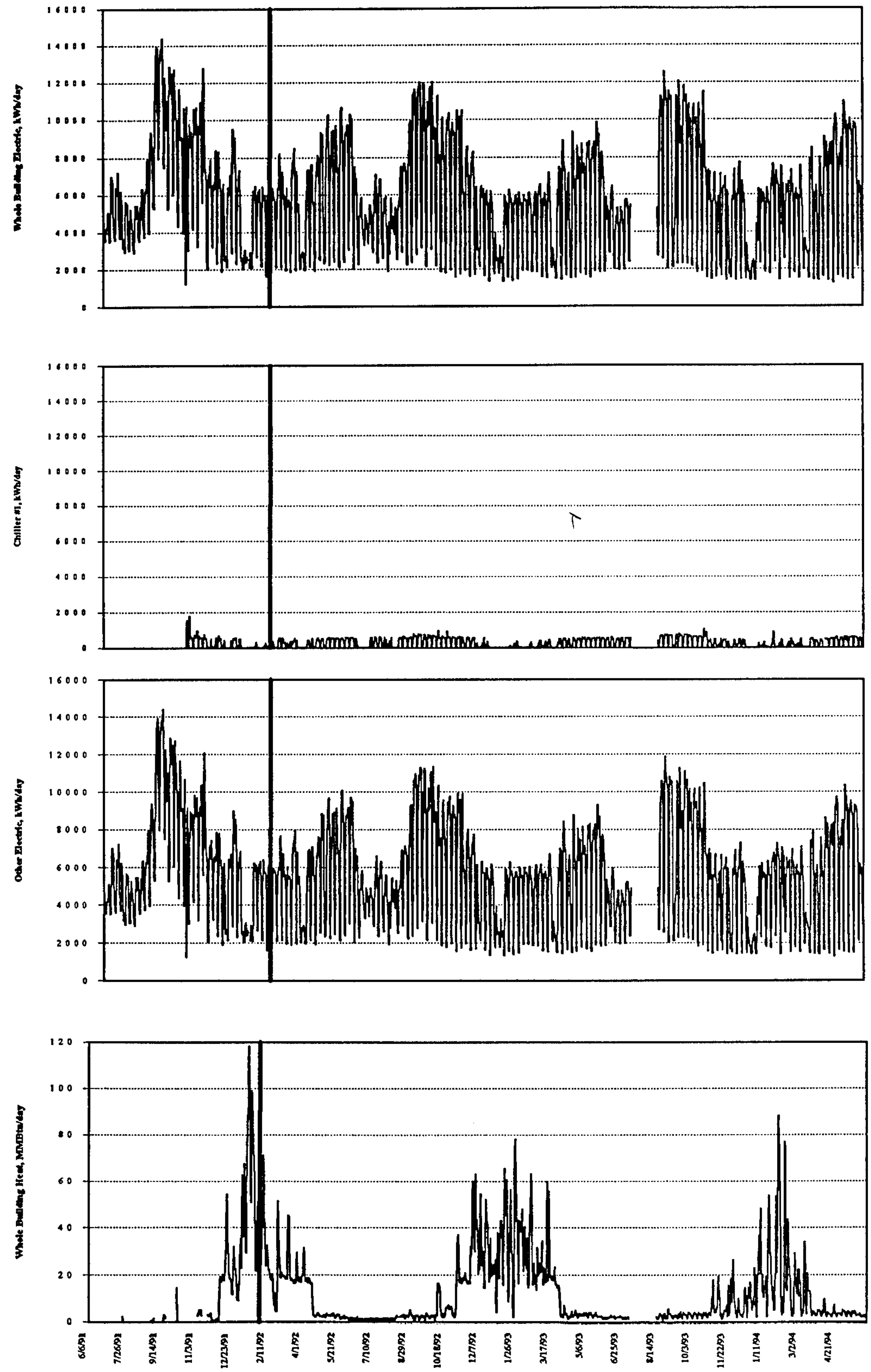

## B.3.2 Timeline plots

Plots of energy consumption for the reporting period are shown in Figure B-3. The EMCS retrofit date of January 31, 1992, is shown by a vertical, bold line. Monitoring diagrams are provided in Tab B-3.

In looking at the whole building electric plot, there is no apparent decrease in consumption at any point along the timeline. There was an a chiller installed as a concurrent retrofit at this site. This resulted in the appearance of chiller consumption in September 1991. Any possible decrease in consumption due to the EMCS may have been offset by the increase in consumption due to the new chiller. The appropriate plot to analyze the effects due only to the EMCS is the "other electric" plot, which is whole building electric minus the chiller. Here, a drop in consumption is evident between the pre-retrofit and post-retrofit periods

The plot of whole building heat shows seasonal heating between November and April of each year. There is also a decrease in consumption evident between the pre-retrofit and post-retrofit periods.

**Figure B-3:** *Energy Consumption time series* **for June 1991 to June 1994 (Victoria High School)**



## B.3.3 Whole Building Electricity Consumption (Post Period)

Table B-1 shows energy consumption for the post period (February 1, 1992, through June 4, 1994). Whole building electricity consumption is broken down into two components: chiller #1 electricity consumption and other electricity consumption. It is further subdivided into semester period and non-semester periods. The post-retrofit period is used because there is significantly more data available in the post-retrofit period, and it represents current usage.

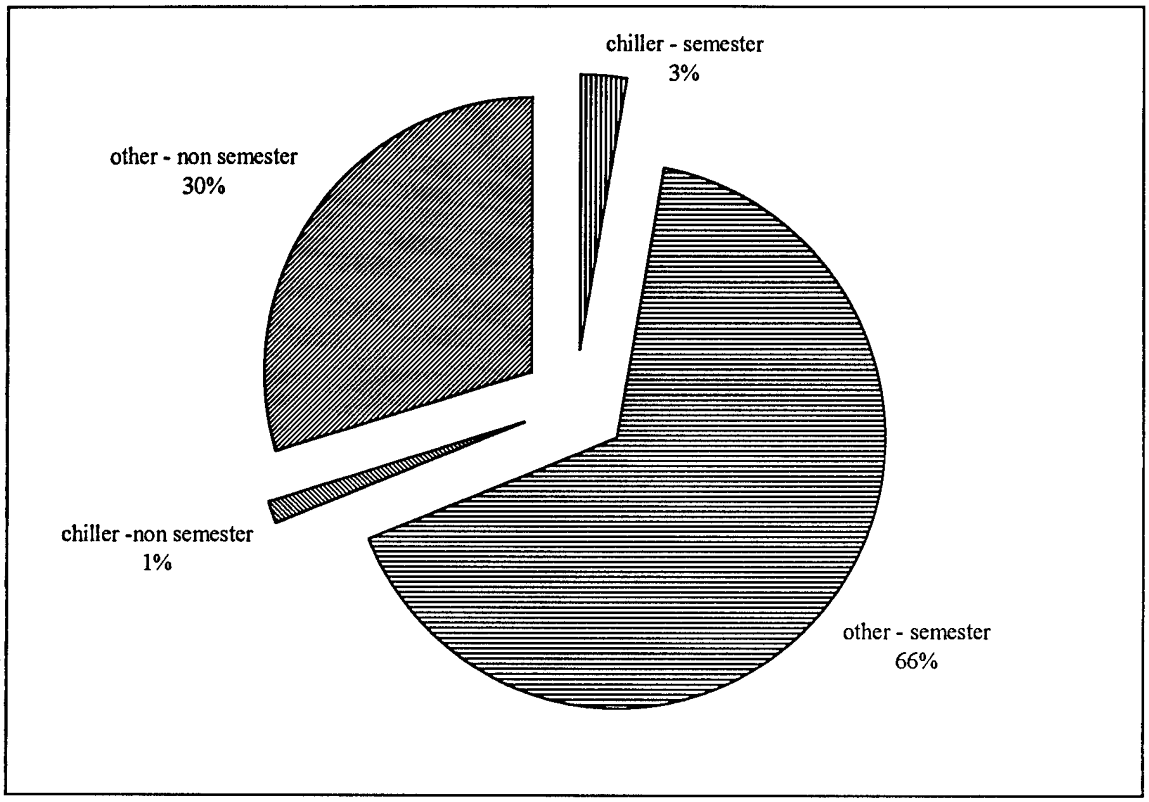
Figure B-4 graphically shows whole building electricity consumption for the post period. For the semester period, 66% of whole building electric energy use is attributable to other electric equipment, while 3% is due to electric chiller #1. For the non-semester period, other electric accounts for 30% of whole building electric energy, while chiller #1 accounts for 1%.

From both Table B-1 and Figure B-4, it is readily apparent that chiller #1 accounts for a small portion of the whole building electricity usage. Therefore, attention for reducing energy usage should be focused on the other electricity usage. In this case, other electricity consumption is primarily roof-top HVAC units and lighting.

**Table B-1:** ***Energy Consumption*** **for post period, February 1992 through June 1994 (Victoria High School)**

| | SEMESTER | | NON-SEMESTER | | TOTAL | |
|---|---|---|---|---|---|---|
| | ENERGY | $ | ENERGY | $ | ENERGY | $ |
| wbelec, kWh | 3,343,246 | $93,210 | 1,262,155 | $35,189 | 4,605,400 | $128,399 |
| chlr #1, kWh | 159,076 | $4,435 | 60,298 | $1,681 | 219,374 | $6,116 |
| other, kWh | 3,184,170 | $88,775 | 1,201,857 | $33,508 | 4,386,027 | $122,282 |
| wbheat, MMBtu | 7,847 | $37,271 | 1,888 | $8,966 | 9,734 | $46,237 |

**Figure B-4:** ***Whole Building Electricity Consumption*** **for post period, February 1992 - June 1994 (Victoria High School)**




## B.3.4 Total Monthly Consumption

The total monthly energy consumption is summarized in Table B-2. Again, it is readily apparent that other electric accounts for the majority of this site's electric energy use.

**Table B-2 :** ***Monthly Energy Consumption*** **(Victoria High School)**

| | wbelec kWh/month | chlr #1 kWh/month | other kWh/month | wbheat MMBtu/month |
|---|---|---|---|---|
| PRE PERIOD | | | | |
| Jun 91 | 121,743 | 0 | 241,636 | 16 |
| Jul | 137,603 | 0 | 220,847 | 21 |
| Aug | 270,742 | 0 | 167,456 | 1 |
| Sep | 276,575 | 0 | 167,304 | 18 |
| Oct | 242,163 | 17,072 | 152,268 | 16 |
| Nov | 160,325 | 5,118 | 136,391 | 45 |
| Dec | 150,396 | 4,642 | 219,845 | 597 |
| Jan 92 | 139,697 | 1,225 | 165,440 | 1,640 |
| Total Consumption | 1,499,242 | 28,057 | 1,471,186 | 2,354 |
| Total Cost | $41,799 | $782 | $41,017 | $10,755 |
| POST PERIOD | | | | |
| Feb 92 | 149,365 | 5,518 | 143,414 | 775 |
| Mar | 141,229 | 4,906 | 161,499 | 664 |
| Apr | 190,903 | 9,330 | 200,369 | 326 |
| May | 227,078 | 12,205 | 244,332 | 78 |
| Jun | 136,443 | 4,319 | 203,001 | 41 |
| Jul | 145,357 | 6,713 | 182,240 | 40 |
| Aug | 199,450 | 11,992 | 142,447 | 65 |
| Sep | 263,715 | 14,623 | 139,716 | 69 |
| Oct | 230,083 | 13,660 | 153,058 | 174 |
| Nov | 159,136 | 7,442 | 171,351 | 685 |
| Dec | 125,653 | 1,982 | 211,597 | 933 |
| Jan 93 | 134,521 | 1,253 | 225,745 | 1,113 |
| Feb | 134,220 | 2,229 | 151,229 | 864 |
| Mar | 147,342 | 5,880 | 155,418 | 674 |
| Apr | 173,404 | 9,780 | 154,491 | 93 |
| May | 194,974 | 11,349 | 159,892 | 89 |
| Jun | 128,470 | 10,102 | 173,318 | 59 |
| Jul | 20,765 | 1,629 | 221,511 | 9 |
| Aug | 153,649 | 8,711 | 138,114 | 49 |
| Sep | 233,928 | 13,954 | 131,201 | 86 |
| Oct | 211,490 | 13,750 | 144,102 | 108 |
| Nov | 135,042 | 5,710 | 209,575 | 258 |
| Dec | 116,966 | 4,896 | 77,688 | 276 |
| Jan 94 | 145,092 | 3,929 | 126,914 | 733 |
| Feb | 145,476 | 4,244 | 38,909 | 756 |
| Mar | 146,811 | 6,386 | 77,542 | 290 |
| Apr | 184,945 | 9,826 | 151,400 | 118 |
| May | 222,895 | 12,802 | 88,572 | 104 |
| Jun 94 | 20,330 | 1,033 | 19,297 | 10 |
| Total Consumption | 4,618,730 | 220,155 | 4,397,944 | 9,538 |
| Total Cost | $128,770 | $6,138 | $122,615 | $45,303 |
| Grand Total Consumption | 6,117,972 | 248,212 | 5,869,129 | 11,891 |
| Grand Total Cost | $170,569 | $6,920 | $163,631 | $56,059 |

## B.3.5 Average Daily Consumption

Figures B-5a and B-5b depict the average hourly consumption for the semester period and the non-semester period. From both figures, you can see that the consumption for the weekdays does not significantly change in profile, but decreases in magnitude, with more significant reductions in the nighttime hours.

For the semester period, Figure B-5a, the weekday consumption slightly decreased during the daytime hours, 7:00 a.m. to 5:00 p.m., and greatly decreased during the nighttime hours, 5:00 p.m. to 7:00 a.m. The weekend consumption decreased during the nighttime, but increased during the daytime hours. Why does the post consumption exceed that of the pre consumption for weekends? One possible explanation is that the setpoints on the new EMCS are such that the consumption is greater during the weekend than before the EMCS was installed. Another possible explanation is that there are many more data points in the post period, and there are periodic special events on the weekends These two factors combined may result in higher weekend daytime consumption in the post-retrofit period.

For the non-semester period, Figure B-5b, weekday consumption slightly decreased during the daytime hours and greatly decreased during the nighttime hours. Here, the weekend usage decreased in a manner similar to that of the weekdays. The changes in both weekday and weekend consumption can be attributed to the EMCS retrofit.

Tab B-4 contains a summary of the hourly averages and the respective standard deviations and count of data points. The hourly averages are the data that is plotted in Figures B-5a and B-5b. For this site, the standard deviations are quite large. They do not vary much for the hours of 0 through 7, then jump to higher levels in hours 8 through 23. This should not be alarming, because the periods that the data were averaged over include wide ranges of temperatures. As was seen earlier, in Figures B-1 and B-2, the energy usage is temperature dependent. The count of data points represents the actual number of data points used to calculate the average, which corresponds to the amount of time that the equipment was actually operating.

**Figure B-5a:** *Semester Pre-/Post-retrofit Comparison* (Victoria High School)

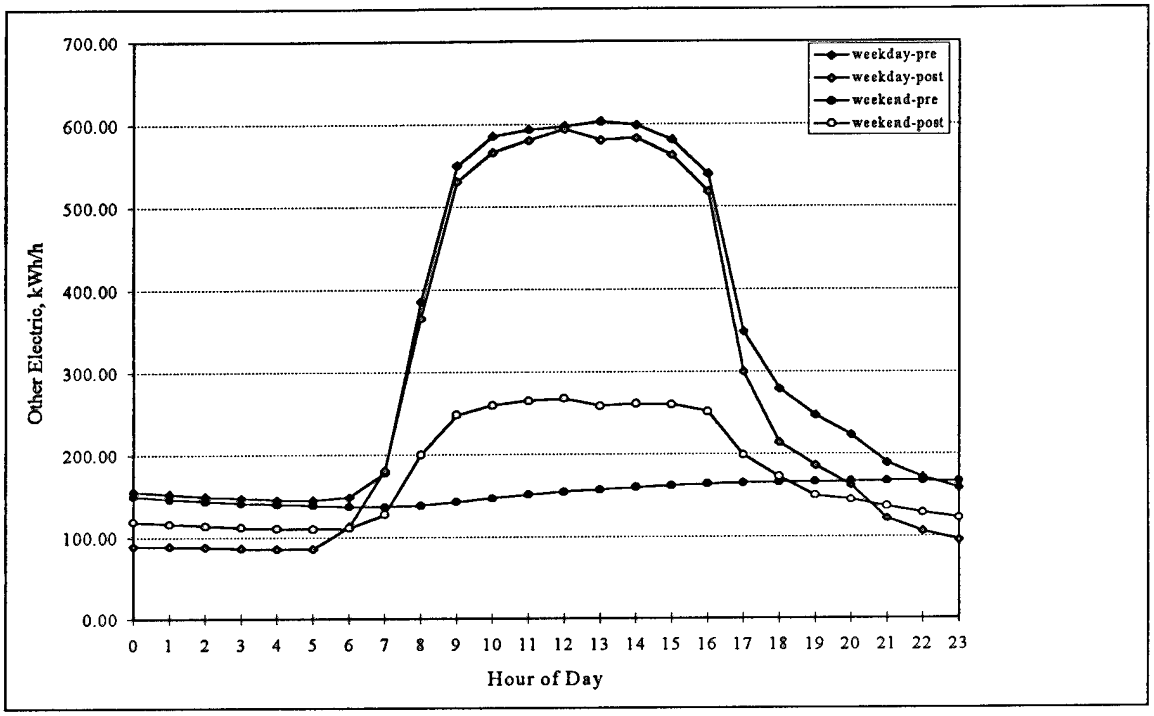
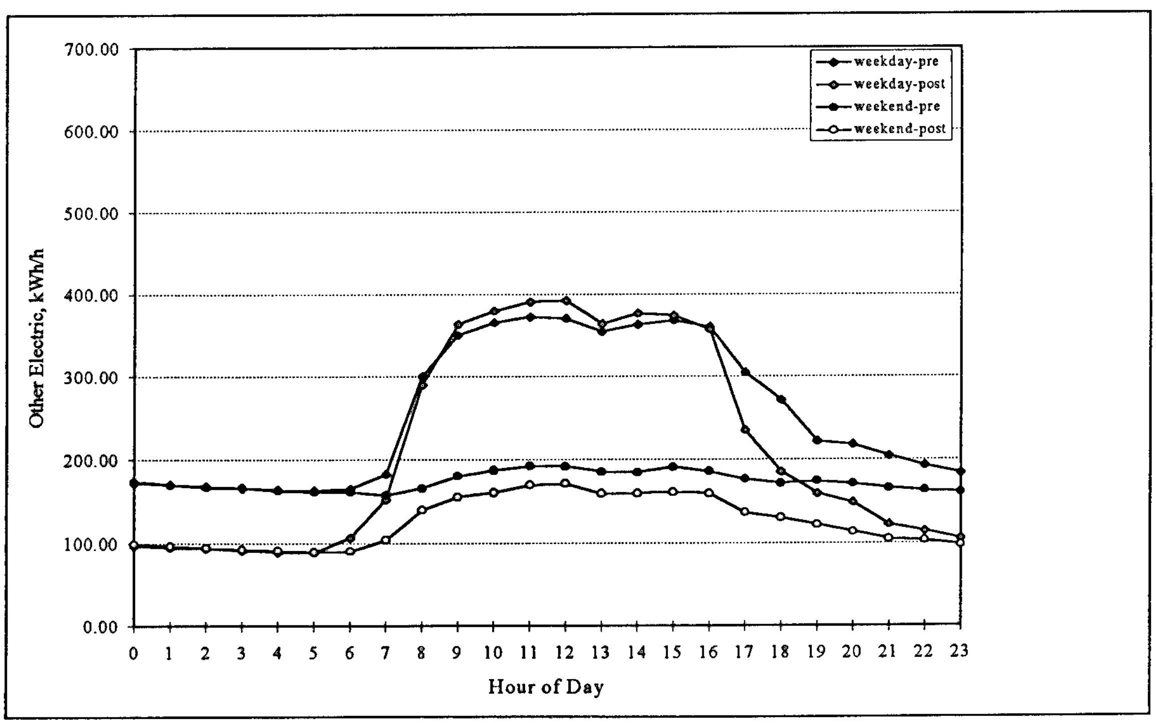



**Figure B-5b:** *Non-semester Pre-/Post-retrofit Comparison* (Victoria High School)



The difference in other electric energy consumption was calculated based on the average daily data. This is shown in Table B-3, both as a difference in energy and a percentage difference in energy.

**Table B-3:** ***Reduction in Other Electric Consumption*** **based on average daily data (Victoria High School)**

| | # days in period | Average Daily Consumption kWh/day | Difference in Average Daily Consumption kWh/period | % Difference in Average Daily Consumption |
|---|---|---|---|---|
| Semester | | | | |
| weekday-pre | 91 | 7,877 | | |
| weekday-post | 394 | 6,889 | -988 | -12.54% |
| weekend-pre | 35 | 3,674 | | |
| weekend-post | 149 | 4,245 | 571 | 15.54% |
| Non-semester | | | | |
| weekday-pre | 79 | 6,159 | | |
| weekday-post | 241 | 5,182 | -977 | -15.86% |
| weekend-pre | 33 | 4,180 | | |
| weekend-post | 92 | 3,017 | -1,163 | -27.82% |

## B.3.6 Plots from MECR

The September MECR energy use plots for four years are shown in Tab B-5. These provide a more qualitative look at the effects of the EMCS. September 1991 is a pre-retrofit plot. Note that there is relatively high consumption between the hours of midnight and 6:00 a.m., with a gradual increase to daytime levels. This is followed by a slow decrease in consumption between the hours of 4:00 p.m. and 10:00 p.m. There are many afternoons and evenings where consumption did not drop to nighttime levels. September 1992 shows dramatically reduced nighttime consumption, with a much sharper slope up to daytime levels between 7:00 a.m. and 8:00 a.m. when compared to September 1991. The consumption drops off much more quickly at 4:00 p.m. and the afternoon and evening consumption is drastically reduced as compared to September 1991.. The profiles are slightly improved between the months of September 1992 and September 1993. The profiles are slightly degraded in September 1994, although are still greatly improved when compared to September 1991. The characteristic post-retrofit shape is maintained, but there are many occurrences of increased nighttime consumption.

Overall, the changes seen in the MECR plots can be attributed to the EMCS retrofit.

It should be noted that these profiles only allow a look at weekday data. The weekend data is unreadable from these plots. Separating the data into weekdays and weekends, then plotting separately would enable one to evaluate weekends, as well as weekdays.

### B.3.7 Data Summary Notebook Information

The Data Summary Notebook information is included in Tab B-6 for information only. It is not analyzed for this site.

## Tab B-1

## School District Schedules

# VICTORIA PUBLIC SCHOOLS
School Calendar 1993-1994

| | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1993 JULY | | | | | 1 | 2 | 3 4 | | 6 | 7 | 8 | 9 | 10 11 | 12 | 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | 22 | 23 | 24 25 | 26 | 27 | 28 | 29 | 30 | 31 | |
| AUGUST | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | | | <18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | 31 | | | | | 10 |
| SEPTEMBER | | | | 1 | 2 | 3 | 4 5 | | | | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | 27 | 28> | <29 | 30 | | | 19 |
| OCTOBER | | | | | | 1 | 2 3 | 4 | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 31 | 21 |
| NOVEMBER | | 1 | 2 | 3 | 4> | <5 | 6 7 | 8 | 9 | 10 | | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22 | 23 | | | | 27 28 | 29 | 30 | | | | | 19 |
| DECEMBER | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | | 18 19 | | | | | | 25 26 | | | | | | | 13 |
| 1994 JANUARY | 1 2 | | | | <6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | 31 | | | | | | 18 |
| FEBRUARY | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17> | <18 | 19 20 | | 22 | 23 | 24 | 25 | 26 27 | 28 | | | | | | 19 |
| MARCH | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | | 12 13 | | | | | | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 | 29 | 30 | 31 | | | 17 |
| APRIL | | | | | | | 2 3 | | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14> | <15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 | 19 |
| MAY | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27> | 29 | 30 | 31 | | | | | 20 |
| JUNE | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | 27 | 28 | 29 | 30 | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Total | 175 |

**Inservice**
September 7-8
January 4-5
February 21
March 11

**Workdays**
August 16-17
January 3
May 28

**Holidays**
July 5 – Holiday
September 6 – Labor Day
November 11 – Veteran's Day
November 24 (1/2)-26 Thanksgiving
December 17 (1/2)-31 Christmas
March 14-18 – Spring Break
April 1-4 – Easter

**Bad Weather Days**
April 4
May 28

**Appraisal Period**
1st Appraisal Period (Level 1)
September 1 - January 21
1st Appraisal Period (Level 2, 3, 4)
September 1 - May 6
2nd Appraisal Period (Level 1)
January 24 - May 6

**No Appraisal Days**
August 18-31
September 3
November 10
November 23-24
December 16-17
March 10, 31
May 9-27

**Early Dismissal**
November 24
(Early Release Day)
December 17
(Early Release Day)

**Graduation:**
Victoria High School May 26
Stroman High School May 27

| Six Weeks | Begins < | Ends > | |
|---|---|---|---|
| First | August 18 | September 28 | 27 |
| Second | September 29 | November 4 | 27 |
| Third | November 5 | December 17 | 28 |
| 1st Semester | August 18 - December 17 | | 82 |
| Fourth | January 6 | February 17 | 31 |
| Fifth | February 18 | April 14 | 31 |
| Sixth | April 15 | May 27 | 31 |
| 2nd Semester | January 6 - May 27 | | 93 |
| | | TOTAL | 175 |

# VICTORIA PUBLIC SCHOOLS
## SCHOOL CALENDAR 1992 - 93

| | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 JULY | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | 27 | 28 | 29 | 30 | 31 | | |
| AUGUST | 1 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | < 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | 31 | | | | | | 9 |
| SEPTEMBER | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 > | < 29 | 30 | | | | 21 |
| OCTOBER | | | | | 1 | 2 | 3 4 | 5 | 6 | 7 | 8 | 9 | 10 11 | 12 | 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | 22 | 23 | 24 25 | 26 | 27 | 28 | 29 | 30 | 31 | 22 |
| NOVEMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 > | < 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | | | | | | 19 |
| DECEMBER | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 | 29 | 30 | 31 | | | 14 |
| 1993 JANUARY | | | | | | 1 | 2 3 | 4 | < 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 31 | 19 |
| FEBRUARY | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 > | < 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | | | | | | | 19 |
| MARCH | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | 29 | 30 | 31 | | | | 18 |
| APRIL | | | | | 1 | 2 | 3 4 | 5 | 6 | 7 | 8 > | 9 | 10 11 | 12 | < 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | 22 | 23 | 24 25 | 26 | 27 | 28 | 29 | 30 | | 20 |
| MAY | 1 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | 31 | | | | | | 19 |
| JUNE | | | 1 | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 | 29 | 30 | | | | |

Total Days 180

**Inservice**
August 17-18
January 4
Feb. 15 Effective Schools
May 28

**Bad Weather Days**
April 12
May 29

**Holidays**
July 4 - Independence Day
September 7 - Labor Day
November 25(1/2)-27 Thanksgiving
December 18(1/2)-January 1 Christmas, New Year
March 15-19 - Spring Break
April 9-12 - Easter

**Appraisal Period**
1st Appraisal Period (Level 1) September 2 - January 8
1st Appraisal Period (Level 2,3,4) September 2 - May 21
2nd Appraisal Period (Level 1) January 11 - May 21

**No Appraisal Days** *
August 19 - September 1
November 24
December 14 - 17
April 8
May 3 - 27
(except for 3rd appraisals)

**Early Dismissal**
September 15
October 12
November 25 (Early Release Day)
December 18 (Early Release Day)
April 28
May 27

**Graduation**
SHS.....May 27
VHS.....May 28

| Six Weeks - Begins | | Ends | |
|---|---|---|---|
| First.......... | Aug. 19 | Sept. 28 | 28 |
| Second....... | Sept. 29 | Nov. 9 | 30 |
| Third......... | Nov. 10 | Dec. 18 | 27 |
| **1st Semester** | | | |
| **August 19 - December 18** | | | 85 |
| Fourth..... | Jan. 5 | Feb. 16 | 30 |
| Fifth........ | Feb. 17 | Apr. 8 | 32 |
| Sixth....... | Apr. 13 | May 27 | 33 |
| **2nd Semester** | | | |
| **January 5 - May 28** | | | 95 |
| | | TOTAL | 180 |

*Revised 6-92

# VICTORIA PUBLIC SCHOOLS
## SCHOOL CALENDAR 1991- 1992

| | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 JULY | | 1 | 2 | 3 | | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | 29 | 30 | 31 | | | | |
| AUGUST | | | | | 1 | 2 | 3 4 | 5 | 6 | 7 | 8 | 9 | 10 11 | 12 | 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | <22 | 23 | 24 25 | 26 | 27 | 28 | 29 | 30 | 31 | 7 |
| SEPTEMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | | | | | | 20 |
| OCTOBER | | | 1 | 2 | 3 | 4 | 5 6 | 7> | <8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21 | 22 | 23 | 24 | 25 | 26 27 | 28 | 29 | 30 | 31 | | | 23 |
| NOVEMBER | | | | | | 1 | 2 3 | 4 | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18> | <19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 | 19 |
| DECEMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | 31 | | | | | 15 |
| 1992 JANUARY | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16> | | 18 19 | <20 | 21 | 22 | 23 | 24 | 25 26 | 27 | 28 | 29 | 30 | 31 | | 19 |
| FEBRUARY | 1 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 | | | | | | | 20 |
| MARCH | 1 | 2> | <3 | 4 | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | 31 | | | | | 16 |
| APRIL | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16> | 17 | 18 19 | 20 | <21 | 22 | 23 | 24 | 25 26 | 27 | 28 | 29 | 30 | | | 20 |
| MAY | | | | | | 1 | 2 3 | 4 | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | 29 | 30 31 | 21 |
| JUNE | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | 29 | 30 | | | | | |

**TOTAL DAYS 180**

**Inservice/Preparation Dates**
August 20-21
January 17
March 13 Effective Schools
May 30

**Bad Weather Days:**
April 20
June 1

Revised June 20, 1991

**Holidays**
July 4 - Independence Day
September 2 - Labor Day
Nov. 27 (1/2)-29 - Thanksgiving
December 20 (1/2) January 3 Christmas, New Year
March 16-20 - Spring Break
April 17 - 20 Easter

**Appraisal Periods**
1st Appraisal Period (Level 1)
September 5-January 10
1st Appraisal Period (Level 2,3, 4)
September 5-May 20
2nd Appraisal Period (Level 1)
January 20-May 20

**No Appraisal Days**
Aug. 21-Sept. 4
Nov. 26
Dec. 20
Jan. 13-16
April 16
May 21-29

**Early Dismissal**
October 23
Nov.27 (Early Release Day)
Dec. 20 (Early Release Day)
April 28
May 29

**Graduation**
VHS....May 29
SHS....May 30

| Six Weeks - | Begins | Ends | |
|---|---|---|---|
| First.......... | August 22........ | October 7 | 32 |
| Second....... | October 8... | Nov. 18 | 30 |
| Third........ | November 19.. | January 16 | 31 |
| 1st Semester | Aug. 22-Jan. 16 | | 93 |
| Fourth........ | January 20.... | March 2 | 31 |
| Fifth.......... | March 3.......... | April 16 | 27 |
| Sixth.......... | April 21....... | May 29 | 29 |
| 2nd Semester | Jan. 20-May 29 | | 87 |
| | | Total | 180 |

# VICTORIA PUBLIC SCHOOLS
## SCHOOL CALENDAR 1990 - 91

| | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | M | T | W | TH | F | S/S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JULY | 1 | 2 | 3 | | 5 | 6 | 7 8 | 9 | 10 | 11 | 12 | 13 | 14 15 | 16 | 17 | 18 | 19 | 20 | 21 22 | 23 | 24 | 25 | 26 | 27 | 28 29 | 30 | 31 | | | | | |
| AUGUST | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | | | | | | | |
| SEPTEMBER | 1 2 | | <4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | | | | | | | 19 |
| OCTOBER | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15> | <16 | 17 | 18 | 19 | 20 21 | 22 | 23 | 24 | 25 | 26 | 27 28 | 29 | 30 | 31 | | | | 23 |
| NOVEMBER | | | | | 1 | 2 | 3 4 | 5 | 6 | 7 | 8 | 9 | 10 11 | 12 | 13 | 14 | 15 | 16 | 17 18 | 19 | 20 | 21 | | | 24 25 | 26> | <27 | 28 | 29 | 30 | | 20 |
| DECEMBER | 1 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | | | 22 23 | | | | | | 29 30 | | | | | | | 13 |
| JANUARY | | | | 2 | 3 | 4 | 5 6 | 7 | 8 | 9 | 10 | 11 | 12 13 | 14 | 15 | 16 | 17 | 18 | 19 20 | 21> | | <23 | 24 | 25 | 26 27 | 28 | 29 | 30 | 31 | | | 21 |
| FEBRUARY | | | | | | 1 | 2 3 | 4 | 5 | 6 | 7 | 8 | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | 25 | 26 | 27 | 28 | | | 20 |
| MARCH | | | | | | 1 | 2 3 | 4> | <5 | 6 | 7 | | 9 10 | 11 | 12 | 13 | 14 | 15 | 16 17 | 18 | 19 | 20 | 21 | 22 | 23 24 | | | | | | 30 31 | 15 |
| APRIL | | 1 | 2 | 3 | 4 | 5 | 6 7 | 8 | 9 | 10 | 11 | 12 | 13 14 | 15 | 16 | 17 | 18 | 19 | 20 21 | 22> | <23 | 24 | 25 | 26 | 27 28 | 29 | 30 | | | | | 22 |
| MAY | | | | 1 | 2 | 3 | 4 5 | 6 | 7 | 8 | 9 | 10 | 11 12 | 13 | 14 | 15 | 16 | 17 | 18 19 | 20 | 21 | 22 | 23 | 24 | 25 26 | | 28 | 29 | 30 | 31> | | 22 |
| JUNE | 2 | 3 | 4 | 5 | 6 | 7 | 8 9 | 10 | 11 | 12 | 13 | 14 | 15 16 | 17 | 18 | 19 | 20 | 21 | 22 23 | 24 | 25 | 26 | 27 | 28 | 29 30 | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Total Days | 175 |

**Inservice**
August 27-31
January 22
March 8 - Optional Inservice
June 1

**Bad Weather Days:**
Instruction.........June 3; June 4
Inservice/Preparation...June 5

**Holidays**
July 4 - Independence Day
September 3-Labor Day
November 22-23 - Thanksgiving
December 20-31, Christmas
January 1 New Year
March 25-29 Spring Break
May 27 - Memorial Day

**Reporting Periods**
First Semester Begins ...September 4
First Semester Ends ......January 21

Second Semester Begins..January 23
Second Semester Ends..........May 31

No Appraisal Days

| | |
|---|---|
| Sept. 4-14 | Jan. 2, 14-18 |
| Nov. 21 | Mar. 22 |
| Dec. 19 | May 23-31 |

**Early Dismissal**
October 24
December 4
February 26
April 16
May 31

**Graduation**
Victoria H.S...........June1
Stroman H.S...........May 31

| Six Weeks - Begins | | Ends | |
|---|---|---|---|
| First.......... | September 4 | October 15 | 30 |
| Second....... | October 16... | November 26 | 28 |
| Third......... | November 27. | January 21 | 31 |
| | | 1st Semester | 89 |
| Fourth....... | January 23... | March 4 | 29 |
| Fifth.......... | March 5.. | April 22 | 29 |
| Sixth.......... | April 23........ | May 31 | 28 |
| | | 2nd Semester | 86 |
| | | Total | 175 |

## Tab B-2

## Audit Technical Analysis

## ECRM DESCRIPTIONS AND CALCULATIONS

**Facility Name:** All Schools

**ECRM No.:** 1

**ECRM Name:** Energy Management System

**a. Summary**

| | | |
|---|---|---|
| Kwh savings: | 1,583,682 | Kwh/yr |
| Demand savings: | 898 | KW-mo/yr |
| MCF savings: | 3,850 | MCF/yr |
| Cost savings: | $95,254 | /yr |
| Implementation cost: | $380,980 | |
| Simple payback: | 4.0 | years |

**b. Description**

On/Off and temperature control in all of the Victoria ISD schools addressed in this report are inadequate. Typically, on/off controls consist of a) 7-day timeclocks which are controlled manually, b) manual control at thermostats or wall switches, and c) programmable thermostats in a very few locations, installed in the last two years. The great majority of on/off control is performed manually, with the result that operating hours are excessive in every school. There is not a single school addressed in this report where on/off control for the majority of HVAC equipment is performed automatically.

Timeclock controls were installed many years ago and are not suited for the needs of the schools.

- There is no way to enforce rigorous hours of HVAC operation if the custodial staff has access to all timeclocks. Even if the timeclocks were functioning with their trippers and the timeclock cabinet were locked, override timers on the face of the timeclock cabinets would allow custodians to turn on HVAC units. The custodians work typically until 9 PM. The natural human tendency is to keep the units on to maintain most comfortable working conditions. Custodial staffs have been instructed on several occasions by the VISD maintenance staff to turn off HVAC promptly after school. Without direct and continuous supervision, one cannot reasonably expect the custodial staff to do so. And they don't.
- The timeclocks offer little flexibility. They typically control multiple HVAC units on one circuit. Often, an entire bank of HVAC units operates when in fact not all are needed. Special events may at time be held outside of normal operating hours. The existing override timers also control banks of units, so -- if the timeclocks and override timers were even used -- more units would operate than necessary.
- There is no feedback with the timeclock system, such as space temperature or humidity readings, and actual operating status of the unit. In several cases, air conditioning takes place 24 hours per day in order to prevent humidity-related problems. Also, heating units may be left on overnight when weather is cold, maintaining temperatures at comfort conditions. Feedback information on space versus outdoor conditions could save a great deal of energy by reducing operating hours.

Summer operation of HVAC systems is also excessive. Schools are cleaned over a period of several weeks during each summer. Depending upon school size, the number of people cleaning, whether summer school is held or not, and the type of cleaning projects taking place, the cleaning process can take up to 6 weeks or more. Often the cleaning crews will turn on air conditioning for entire schools or wings of schools, regardless of how many rooms are actually being cleaned, since the method of turning units on is to flip a master timeclock switch which turns on whole banks of units. Again, virtually all control is manual through thermostats or timeclock master trippers. In addition to air conditioning schools for personal comfort, the cleaning crew operates the air conditioning to speed up drying of floors and other surfaces cleaned. Also, some teachers start coming to school by mid August. Typically, air conditioning throughout an entire school is again turned on, even though the number of teachers occupying the school is very small.

Temperature controls are virtually all open to occupant adjustment. The number of locking thermostats in all schools addressed in this report can be counted on one hand, and some of those are not locked. Typical settings are in the low 70's (deg F).

Even the programmable thermostats of the most recently installed HVAC units offer less than ideal control. The units inspected were programmed for 6 AM to 6 PM operation. While this schedule covers most occupancy demands, it is generally excessive. Neither teachers nor staff reprogram the thermostats as their occupancy needs differ.

Though the quantity of timeclocks and HVAC units may vary by school, the control methodology described above is typical of all the schools in this report. Controls in each school are addressed individually below. A summary of On/Off times follows (as determined by interviews with custodial staffs), starting on page 80.

Aloe Elementary

There are four timeclocks located in a small janitorial room in the main wing. Each is a 7-day timeclock. Clock #1 controls the library unit, #2 the kitchen, #3 the offices and classrooms, and #4 the cafeteria units. There are override toggle switches in the face of the timeclock cabinet, one for each timeclock. However, as the timeclocks are not used as originally intended, the overrides are useless. On each timeclock, on/off trippers have been removed, and the custodial staff uses the master on/off tripper to control units. All units are turned on manually by custodians at about 6:30 - 7:00 AM. The custodial staff works after school until 9 PM, and turns the units off when they leave.

In the 3rd/4th grade wing and the kindergarten wing, programmable thermostats have been installed. On/off times are 6 AM to 6 PM, Monday through Friday.

De Leon Elementary

There are two timeclock stations in the school. The first station, located behind the library, has four 7-day timeclocks. The second station, located in an electrical room in the south classroom wing, has three 7-day timeclocks. There is an override toggle switch for each timeclock. These seven timeclocks control the seven rooftop HVAC units installed with the original school. HVAC units 8 - 11 were added with the new classroom addition. They are controlled directly from individual room thermostats, not by timeclock.

All units are controlled manually by the custodial staff using the timeclock master on/off tripper, and room thermostats. Operating hours are from 6 AM until 8 PM.

Dudley Elementary

There are three 7-day timeclocks located in the electrical room across the hall from the cafeteria. The first controls classroom and office units, the second the kitchen, and the third the cafeteria. All units are controlled manually by the custodial staff using the timeclock master on/off tripper. On/off hours are typically 7 AM to 7 PM, Monday through Friday.

Hopkins Elementary

There are four rooms which contain timeclocks at Hopkins. The main mechanical room has four 7-day timeclocks, controlling direct expansion units for 1) the office area, 2) the library, 3) the kitchen, and 4) the cafeteria. There is a single 7-day timeclock in the north wing, one in the south wing, and one in the middle wing. Each controls HVAC fan-coil units and chillers/pump for their respective wing. Most or all trippers have been removed from all timeclocks, and all are operated manually.

All units are turned on manually by custodians at about 6:00 AM. The custodial staff works after school until 9 PM, and turns the units off when they leave.

Howell Intermediate

There is a main control panel at Howell Intermediate located in the main mechanical room. Toggle switches are located in the face of the panel for controlling virtually all HVAC units in the school. When the custodian arrives at 6:30 AM, he turns on all HVAC units via the toggle switches, and the chiller if necessary. He always turns on the boiler, no matter what the weather conditions, since the HVAC system at Howell is reheat. Another custodian turns off HVAC equipment around 7 PM.

In summer, the same procedure is followed for the approximately six weeks cleaning period.

Juan Linn Elementary

All HVAC units installed with the 1986 addition are controlled by programmable thermostats. Programmed on/off times are 6 AM on, and 6 PM off, Monday through Friday. The one exception is the library unit. It has a programmable thermostat, but the unit remains in operation continuously out of concern for mildew on library books. The two rooftop units over the original (east) classroom wing have been replaced recently, and are controlled by programmable thermostats also.

All fan-coil units and the chiller of the stand-alone 1951 addition are controlled by 7-day timeclock located by the east entrance to the building. All trippers to the clock have been removed. The janitor operates the master timeclock tripper to control HVAC.

In the main building, the custodian turns units on manually at the thermostats when she arrives at 6:45 AM, and another custodian turns units off around 8 PM.

Summer school is held in Juan Linn for six weeks. Again, custodians turn equipment on/off manually. However, most units are turned off earlier in the day as compared to the regular school year.

O'Connor Elementary

Two rooms contain 7-day timeclocks at O'Connor, one in the north wing and one in the south. All units are turned on manually by custodians at about 6:30 AM, and off at around 8:00 PM. The east wing addition units are controlled manually by custodians via their thermostats.

There are two locking thermostats in the north wing, but neither was locked when seen.

Shields Elementary

The majority of floor area in Shields is served by hydronic fan-coil units. Control is the same as in all other elementaries: 7-day timeclocks exist, but custodial staff uses only the master trippers to turn units on and off when they arrive and depart. Units are turned on around 7 AM, and off about 6:30 PM.

Stanly Elementary

Control of HVAC units in Stanly is identical to O'Connor. The two schools originally had identical floor and HVAC plans. Timeclocks are located in exactly the same rooms as in O'Connor.

Stroman High School

Control of HVAC units at Stroman requires very intensive footwork. The custodian makes rounds to every air handling unit, most fan-coil units, many direct expansion units, and the chiller/boiler/auxiliary equipment each morning around 6:45 AM, where he turns equipment on. Another custodian makes a similar round at about 8:30 PM to turn equipment off.

The kitchen staff turns kitchen HVAC on and off. The coaching staff turns athletic building HVAC off, and the custodial staff turns it back on in the morning, though often the coaching staff forgets to turn units off.

A small (46 ton) reciprocating chiller is located adjacent to the four story Unit A. This chiller is piped to serve only Unit A. During summer and after school hours, parts of Unit A (which contains administrative offices) are the only occupied portions of the school. At 4:30 PM during the school year, the absorption chiller is shut down and the reciprocating chiller is turned on, and continues to operate until 9 PM. In summer, the reciprocating chiller is turned on 7:00 AM, and off at 6:00 PM, unless the main chiller is operating.

Direct expansion split systems serving the Band hall are thermostatically controlled, but are left in operation continuously, summer and winter. If the main air handler serving Band has been shut off and indoor temperature starts to rise, the DX units will maintain humidity and temperature conditions. These backup DX units were installed out of concern for humidity-related problems with Band instruments.

Summer cleaning of the high school takes about 5 to 6 weeks. During this time, the main absorption chiller operates every day, and virtually the entire school is cooled. Cleaning is finished by mid- to late-July, and only the reciprocating chiller operates after that.

Victoria High School

Victoria High is another school requiring intensive footwork in turning HVAC systems on and off. The VHS campus contains numerous buildings spread out over a wide geographical area. The maintenance man starts his round at 7 AM to all mechanical rooms and thermostats/wall switches, turning on equipment. As at Stroman, the coaching staff is responsible for turning off some athletic building HVAC equipment (though they often forget) and the maintenance man turns it back on in the morning.

There are two rooftop units over the Learning Resource Center. During the regular school year, these operate from 7:15 AM until 4 PM. During summer, one of the units is shut down, but the other remains in operation 24 hours per day to prevent problems with mildew. Starting in September, HVAC for the boys dressing room is left on continuously until cold weather hits, so as to reduce odor problems which are worsened by heat and humidity.

Summer school is held in the Academic Wing of VHS, and occasionally in the main wing. The Academic Wing is served by the absorption chiller. The chiller is turned on at 6:30 AM, and off at 1:30 PM. The fan-coil units served by the chiller remain in operation continuously, both summer and winter. The on/off switches for them are located inside the units.

Fan-coil units for the main building are controlled by toggle switches mounted on the wall of each classroom. Teachers are supposed to turn these units off as they leave each day, and the maintenance staff turns them back on in the morning. However, as often as not, the fan-coil units are left on at night.

This ECRM calls for the installation of a direct digital control-based energy management system (EMS) for each school addressed in this report. The EMS will control all HVAC equipment, measure exterior and interior space temperatures, and measure humidity in one or two critical locations within each school. The EMS will have no override timers that custodial staffs can activate. Operating hours of all HVAC units will be determined by the maintenance staff, and controlled by that staff from its central headquarters via modem. (Floor plans on pages 27 through 37 show locations of the units to be controlled, and the proposed locations of new DDC controllers).

## Tab B-3

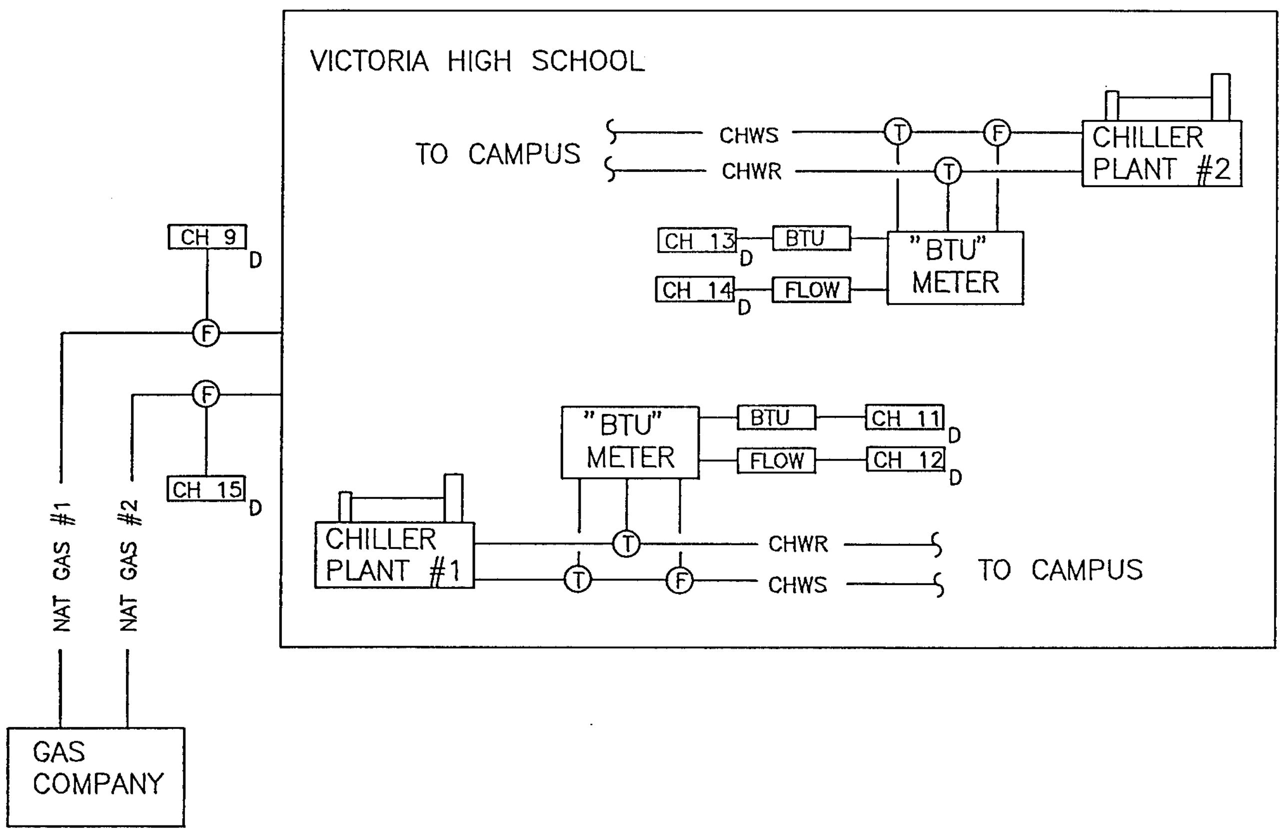
## Monitoring Diagrams

# THERMAL MONITORING DIAGRAM

# VISD – VICTORIA HS

**LEGEND**

K=KWH CHANNEL
A=ANALOG CHANNEL
D=DIGITAL CHANNEL
PC=PUMPED CONDENSATE




VISD/VICTORIA HS – SITE 127

# ELECTRICAL MONITORING DIAGRAM

## VISD — VICTORIA HS

LEGEND

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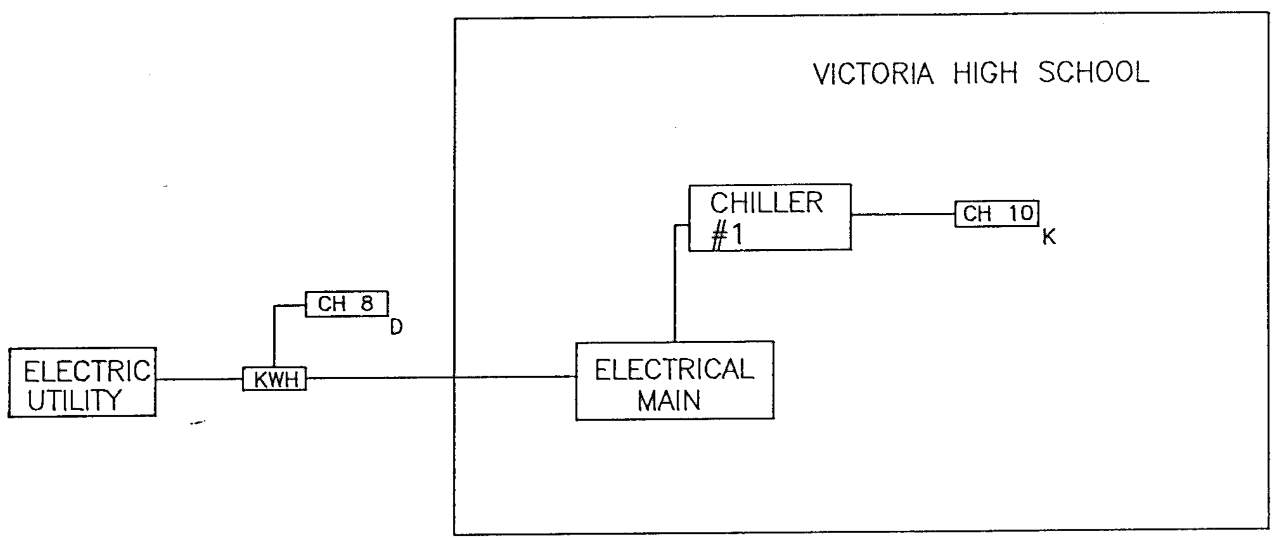
A=ANALOG CHANNEL
D=DIGITAL CHANNEL




VISD/VICTORIA HS — SITE 127

# Tab B-4

## Average Hourly Data & Related Statistics

### Hourly Average

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 155.8478 | 152.7411 | 149.7756 | 147.4356 | 145.5722 | 144.9667 | 148.6356 | 177.9144 | 385.7067 | 550.3722 | 585.8678 | 593.8933 | 597.5478 | 602.9189 | 598.7422 | 580.9522 | 540.2400 | 348.3775 | 279.1622 | 247.2538 | 223.2769 | 189.3615 | 171.3736 | 158.8582 |
| 1-B-S | 89.3124 | 88.7661 | 88.2294 | 86.6309 | 85.5415 | 85.8901 | 112.8985 | 181.1843 | 365.0458 | 531.4911 | 566.4124 | 580.8182 | 594.3167 | 580.8433 | 583.0823 | 563.0736 | 518.8949 | 300.1294 | 213.9661 | 186.2623 | 162.1997 | 121.8235 | 106.1149 | 95.6559 |
| 0-A-S | 150.2361 | 146.3556 | 143.7796 | 141.6625 | 139.8533 | 138.3639 | 137.2004 | 136.4774 | 137.9741 | 142.5008 | 146.4912 | 150.8502 | 154.5609 | 157.1383 | 159.6657 | 162.0158 | 163.8940 | 165.0974 | 165.7601 | 166.4178 | 166.8171 | 167.0696 | 167.0926 | 166.8375 |
| 0-B-S | 118.9952 | 116.2991 | 113.6498 | 111.7100 | 110.4886 | 109.5664 | 111.0122 | 127.6799 | 199.8214 | 247.9293 | 259.5539 | 265.1860 | 267.7734 | 258.7105 | 261.2576 | 260.1428 | 251.5694 | 198.8821 | 172.4642 | 149.8079 | 144.5210 | 136.1297 | 129.0083 | 122.3419 |
| 1-A-NS | 172.7456 | 170.4848 | 168.6785 | 166.1165 | 164.7354 | 163.7266 | 165.6051 | 183.2089 | 300.4506 | 350.5038 | 365.7974 | 372.1628 | 370.3848 | 354.2342 | 363.2329 | 367.9722 | 360.2241 | 304.8911 | 271.6025 | 222.2127 | 218.0772 | 204.7570 | 193.1266 | 184.1709 |
| 1-B-NS | 97.7263 | 95.5989 | 94.2586 | 91.8952 | 90.2855 | 89.5016 | 106.9328 | 153.1672 | 289.3108 | 363.5968 | 379.4683 | 390.7246 | 392.4877 | 364.0722 | 376.6465 | 374.0893 | 357.0952 | 235.5791 | 185.8909 | 160.1214 | 149.8390 | 123.3888 | 114.9471 | 105.7818 |
| 0-A-NS | 174.2824 | 170.3676 | 167.7176 | 166.9412 | 163.7588 | 161.9176 | 162.1382 | 158.1500 | 166.3118 | 180.6618 | 187.4824 | 192.5853 | 191.9941 | 186.0559 | 185.1794 | 191.2294 | 186.4765 | 176.6912 | 171.9794 | 174.5441 | 171.4471 | 166.3059 | 163.8735 | 161.7118 |
| 0-B-NS | 100.2916 | 97.1494 | 94.6988 | 93.1651 | 91.8386 | 89.9723 | 91.0494 | 104.5373 | 140.1843 | 156.4614 | 161.0373 | 169.7205 | 171.7169 | 159.8964 | 160.3843 | 161.6373 | 160.2265 | 137.1976 | 131.0952 | 122.8687 | 114.0325 | 105.5627 | 103.6549 | 98.2373 |

### Standard Deviation of the Hourly Average

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 67.9273 | 65.8407 | 64.4460 | 64.0302 | 62.1425 | 63.0211 | 76.6243 | 84.8685 | 143.0978 | 160.0605 | 164.0983 | 167.0280 | 176.4669 | 178.2542 | 185.3368 | 182.8285 | 171.0840 | 93.8461 | 83.8911 | 73.0449 | 74.9759 | 74.2153 | 57.0681 | 49.9828 |
| 1-B-S | 21.6861 | 23.2511 | 21.8800 | 20.4019 | 19.7393 | 18.2540 | 42.1464 | 89.9723 | 146.9820 | 182.8566 | 194.2151 | 202.4603 | 205.4641 | 204.4085 | 212.6136 | 201.7983 | 192.0298 | 90.9103 | 54.4984 | 53.8733 | 55.5336 | 53.0611 | 33.8103 | 23.5994 |
| 0-A-S | 43.5057 | 43.0013 | 42.3353 | 41.7549 | 41.0891 | 40.3630 | 39.8338 | 39.6245 | 42.3022 | 52.9168 | 60.5251 | 66.5132 | 70.8013 | 73.7412 | 76.0021 | 77.8402 | 78.8368 | 79.0945 | 79.1357 | 79.0952 | 79.0873 | 79.2978 | 79.4792 | 79.4952 |
| 0-B-S | 66.4774 | 65.5404 | 64.2651 | 63.3212 | 62.2459 | 61.8243 | 63.8720 | 80.7031 | 159.2085 | 210.6429 | 225.3422 | 230.1577 | 239.1506 | 235.4430 | 236.0238 | 233.4913 | 219.4059 | 143.1721 | 118.8526 | 98.5710 | 91.7394 | 84.1196 | 78.5033 | 75.1915 |
| 1-A-NS | 86.0271 | 83.9045 | 81.7709 | 80.8673 | 78.9099 | 78.3911 | 82.2422 | 98.1746 | 159.6581 | 197.3159 | 210.9832 | 215.4262 | 225.4947 | 217.6331 | 219.4239 | 221.8663 | 208.0452 | 152.2857 | 134.0336 | 121.7042 | 111.2659 | 105.3279 | 100.6155 | 97.3309 |
| 1-B-NS | 24.3434 | 24.8851 | 25.1825 | 23.1370 | 22.0268 | 20.5988 | 43.2421 | 92.3067 | 192.8601 | 252.2756 | 261.3779 | 268.5710 | 270.0534 | 268.7850 | 270.7709 | 263.0763 | 252.2683 | 123.5556 | 80.5049 | 61.5697 | 53.8798 | 42.1642 | 37.1048 | 29.9683 |
| 0-A-NS | 87.5901 | 86.1269 | 83.8935 | 81.0950 | 79.3833 | 79.1197 | 76.3466 | 76.0481 | 82.0064 | 108.2841 | 113.6487 | 112.1341 | 113.8832 | 104.7284 | 101.6120 | 105.0255 | 105.8376 | 80.8195 | 80.1987 | 76.6572 | 74.3330 | 76.4056 | 75.2121 | 73.0585 |
| 0-B-NS | 33.3462 | 31.3063 | 29.9837 | 28.7899 | 28.6849 | 26.9378 | 27.4354 | 47.3277 | 121.3100 | 163.0854 | 171.2064 | 176.9169 | 178.1092 | 163.9776 | 165.1637 | 163.7218 | 155.3629 | 86.2512 | 68.1023 | 59.6414 | 47.6750 | 35.4916 | 32.1089 | 29.4605 |

### Count of Data Points

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 89 | 90 | 91 | 91 | 91 | 91 | 91 |
| 1-B-S | 394 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 395 | 394 | 393 | 395 | 395 | 395 | 395 | 395 | 395 | 395 |
| 0-A-S | 36 | 72 | 108 | 144 | 180 | 216 | 252 | 288 | 324 | 360 | 396 | 432 | 468 | 504 | 540 | 576 | 612 | 648 | 684 | 720 | 756 | 792 | 828 | 864 |
| 0-B-S | 229 | 228 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 228 | 228 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 |
| 1-A-NS | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 78 | 78 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 |
| 1-B-NS | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 |
| 0-A-NS | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 |
| 0-B-NS | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 82 | 83 |

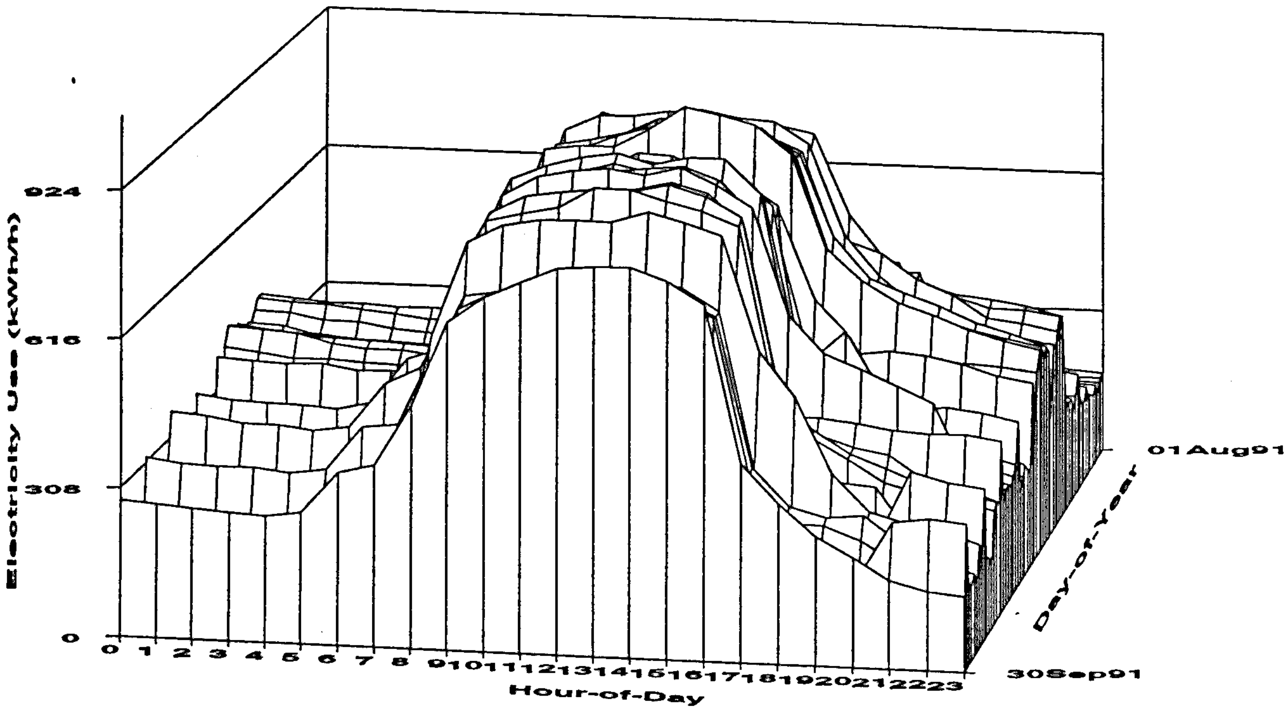
### Key

| | | |
|---|---|---|
| 1-A-S | = | Semester/Weekday/Pre-Retrofit |
| 1-B-S | = | Semester/Weekday/Post-Retrofit |
| 0-A-S | = | Semester/Weekend/Pre-Retrofit |
| 0-B-S | = | Semester/Weekend/Post-Retrofit |
| 1-A-NS | = | Non-Semester/Weekday/Pre-Retrofit |
| 1-B-NS | = | Non-Semester/Weekday/Post-Retrofit |
| 0-A-NS | = | Non-Semester/Weekend/Pre-Retrofit |
| 0-B-NS | = | Non-Semester/Weekend/Post-Retrofit |

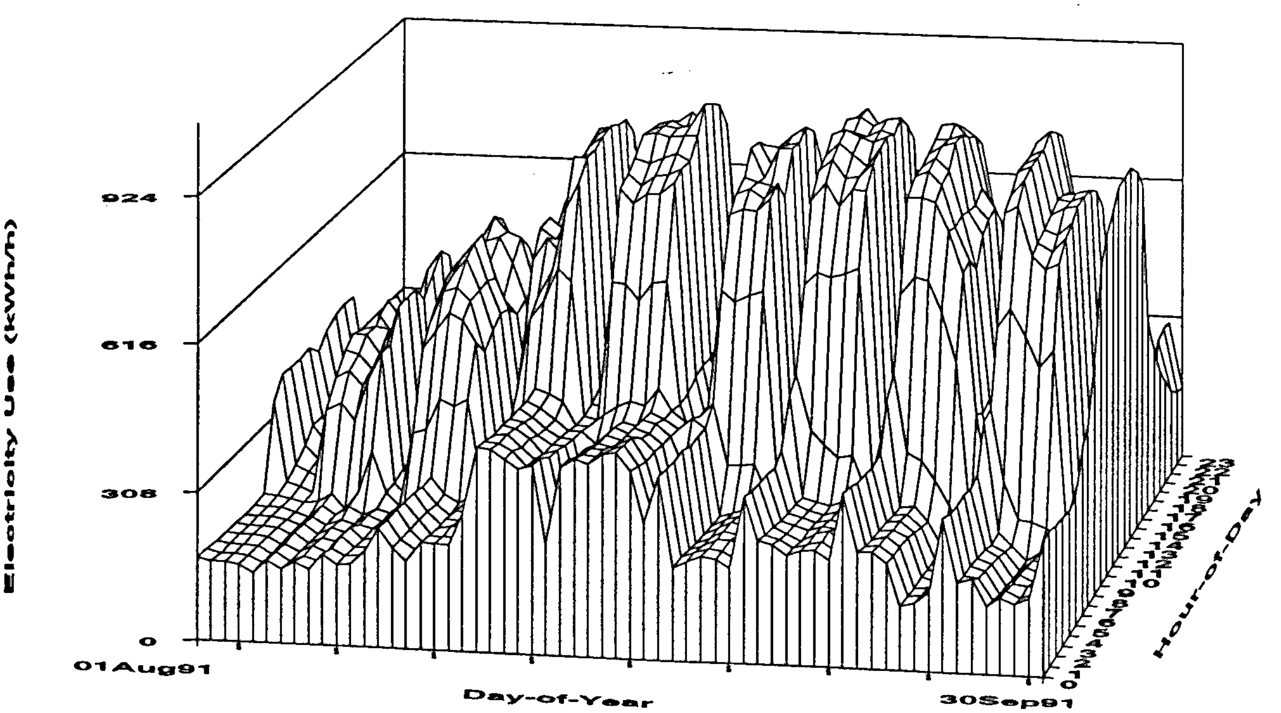
# Tab B-5

## MECR Plots

Whole–Building Electric



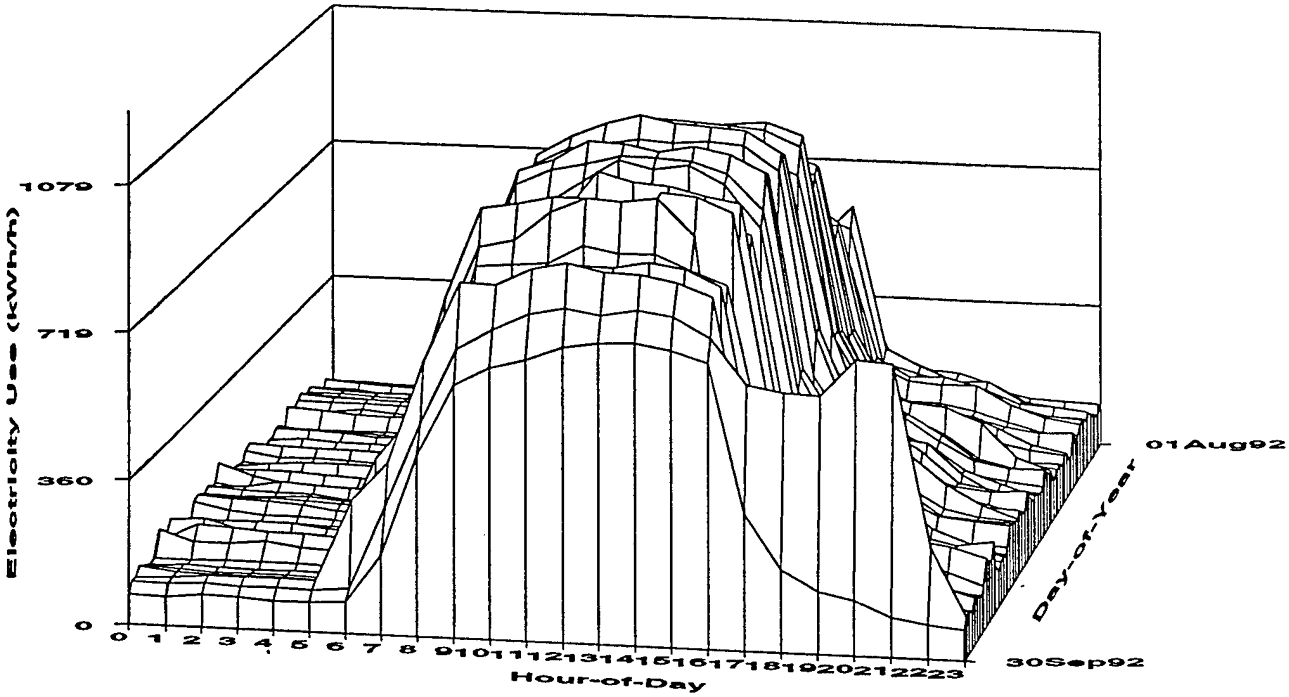

Whole–Building Electric



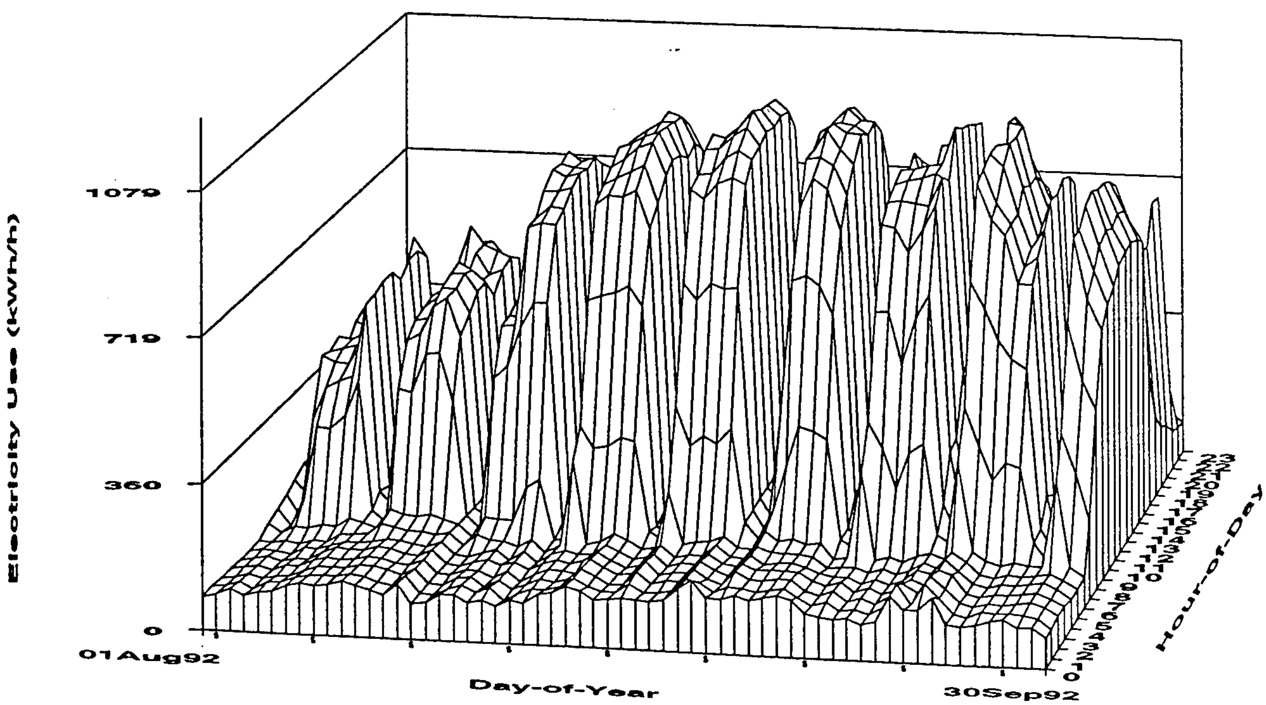

Sundays are marked with an "S"

Victoria High School - Victoria ISD - September 1991

Whole–Building Electric



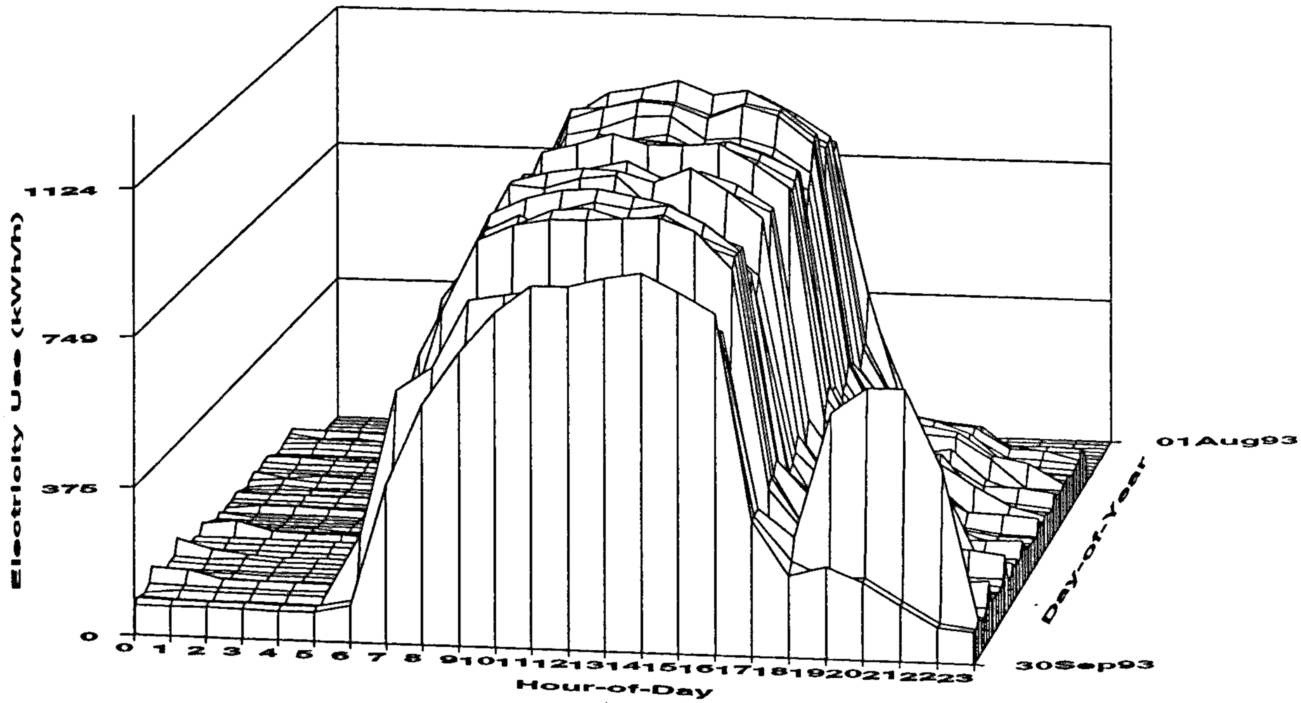

Whole–Building Electric



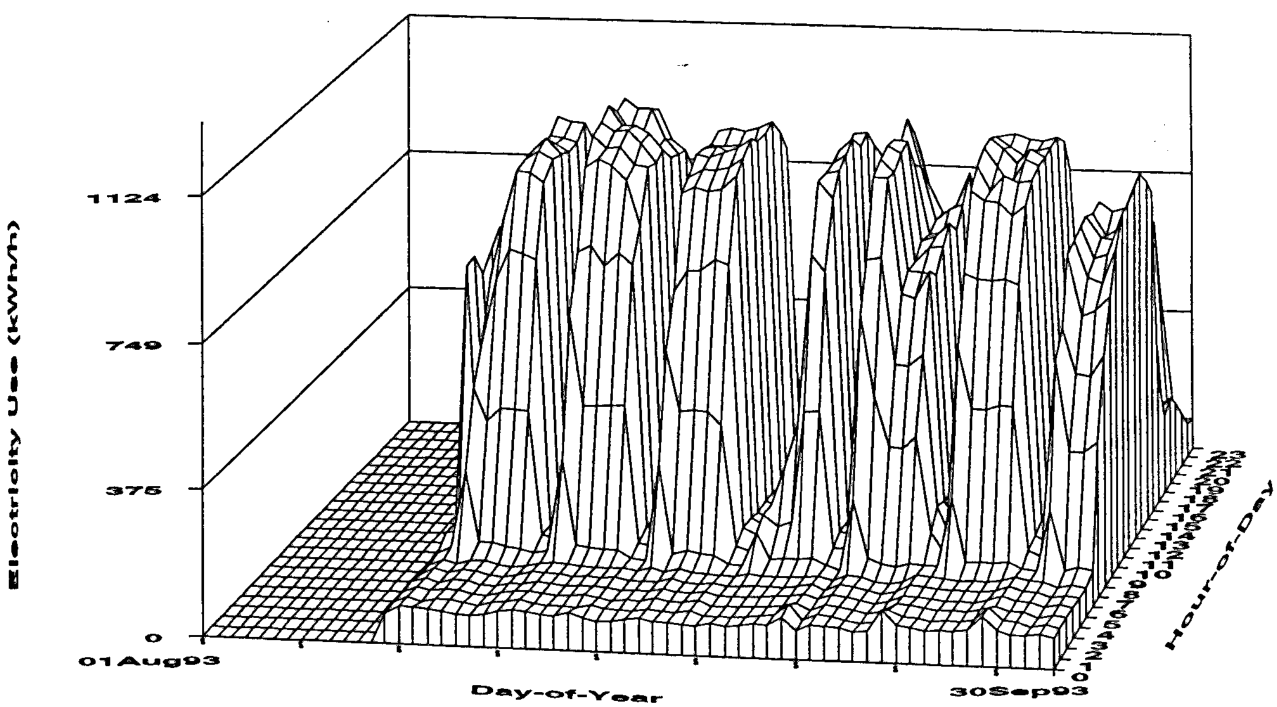

Sundays are marked with an "S"

Victoria High School - Victoria ISD - September 1992

# Whole–Building Electric

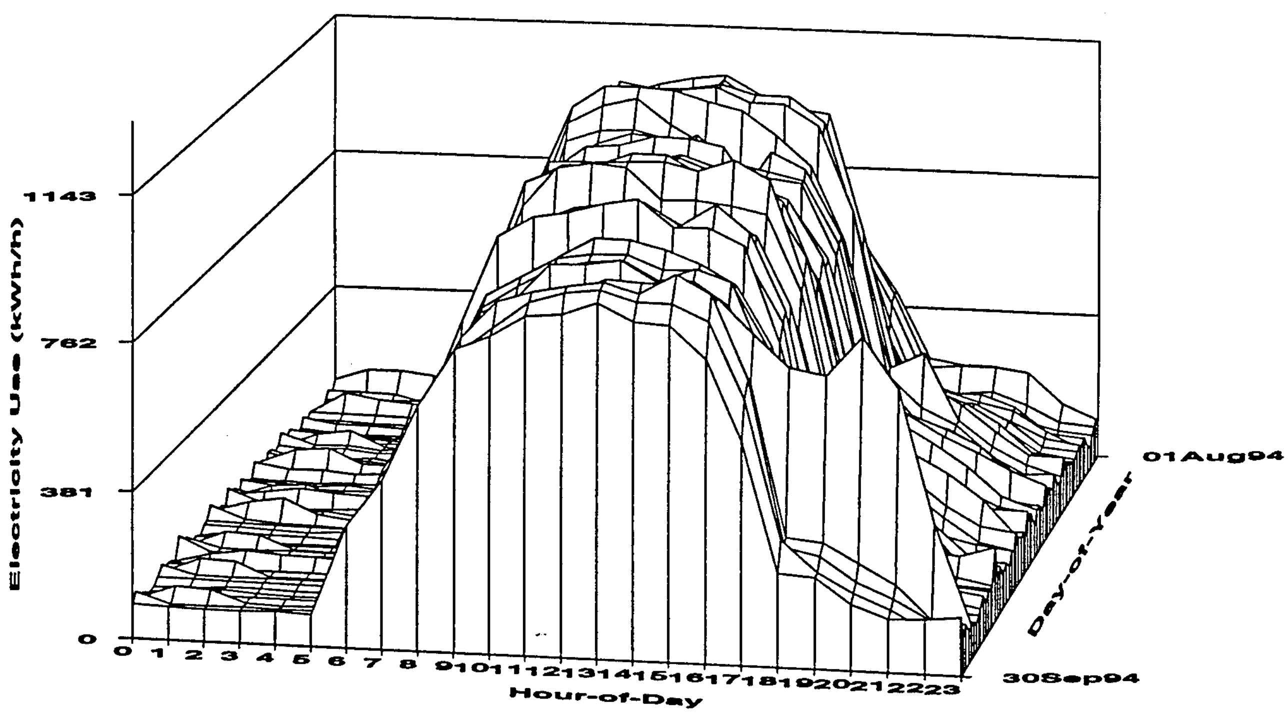



# Whole–Building Electric

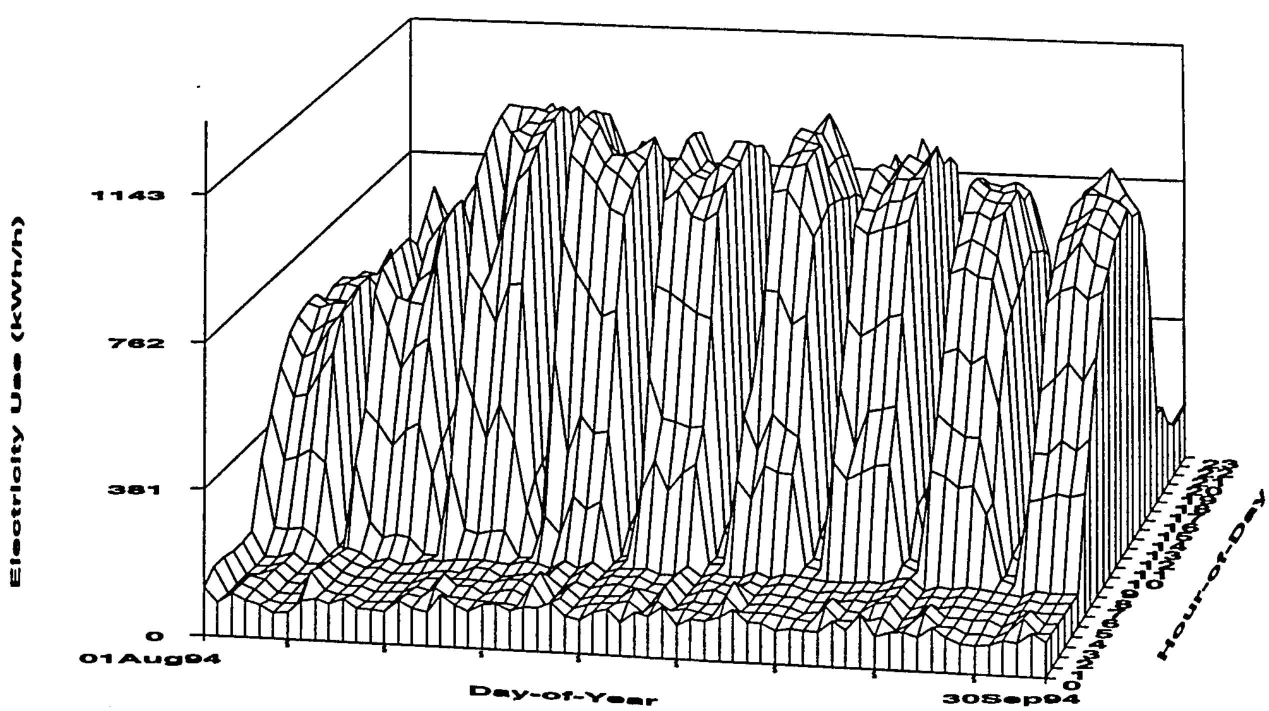



Sundays are marked with an "S"

Whole-Building Electric




Whole-Building Electric




Sundays are marked with an "S"

Victoria High School - Victoria ISD - September 1994

# Tab B-6

## Data Summary Notebook Information

# VICTORIA INDEPENDENT SCHOOL DISTRICT
## Victoria High School

**Building Envelope:**
- 257,000 sq.ft.
- Main Building: Two stories, brick slab, and grade construction with flat roof, 54,000 sq ft.
- Academic Building: same as Main Building, 60,700 sq ft.
- Field house (dressing room, 2-shop buildings, gymnasium, special education building, learning resource center, home economics building, a multi-purpose building with kitchen, cafeteria, band hall and choir room are all one story.), 142,300 sq ft.

**Building Schedule:**
- 7 am to 4 pm (M-F)

**Building's HVAC & other equipment:**

**Main building:**
- 17 rooftop units (4 - 7.5 tons)
- 70 fan-coil units each 0.17hp
- 1-192 ton Trane centrifugal chiller
- 1 boiler

**Academic Wing:**
- 1-25% O.A 7.5hp AHU
- 112 - 0.05hp fan-coil units and 6 - 0.17hp fan-coil units
- 1-182 ton York centrifugal chiller (replaced absorption chiller in Aug 91)

**Field House**
- boys dressing room: 8 rooftop units (2-5 tons and 4-7.5 tons).
- Vocational: rooftop unit
- Industrial Arts: 2 rooftop units (15 tons each).
- Gymnasium: 1 rooftop unit (3.0 tons) and 1 steam boiler.
- Home Economics: 1 rooftop unit (15 tons).
- Kitchen: 1 rooftop unit (7.5 tons).
- Cafeteria: 1 rooftop unit (7.5 tons).
- Band Hall: 3 rooftop units (1-10 tons and 1-5 tons).
- Choir: 3 rooftop units (1-5 tons).
- Special Education: rooftop unit (7.5 tons).
- Learning Resource Center: 2 rooftop units (15 tons each).

**Auxillary Equipment:**
- 2 CHWPs, 1 of 25 hp, 1 of 20hp
- 2 CWPs, 1 of 25 hp, 1 of 15 hp
- 2 Cooling towers, 1 of 15hp, 1 of 20 hp
- 1 HWP of 5hp
- 1 Brine pump
- 1 Refrigerant pump
- 2 Boilers
- 10 Exhaust fans (1/2 hp each)

**Lighting:**
- Mostly fluorescent (Total load 260 kW).

**HVAC Schedule:**

- HVAC equipment is turned on manually at 6:00 a.m. and turned off at 8:00 p.m. on weekdays.

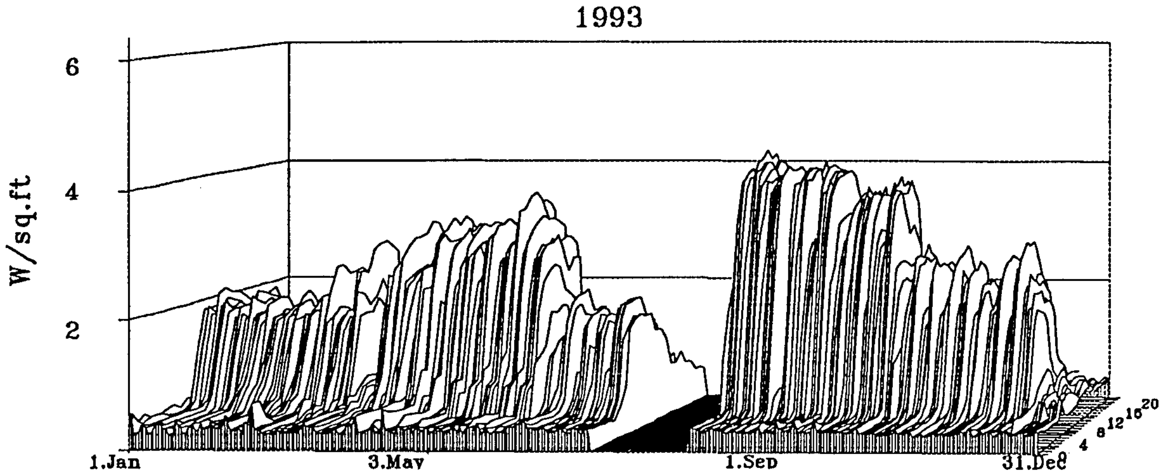
**Proposed Retrofits:**

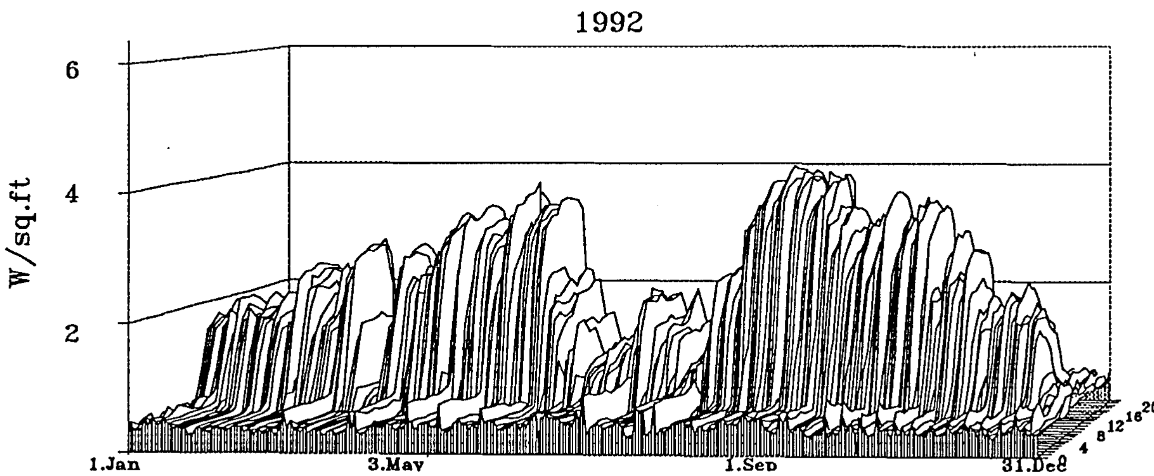
- Energy Management System
- Replace Absorption chiller

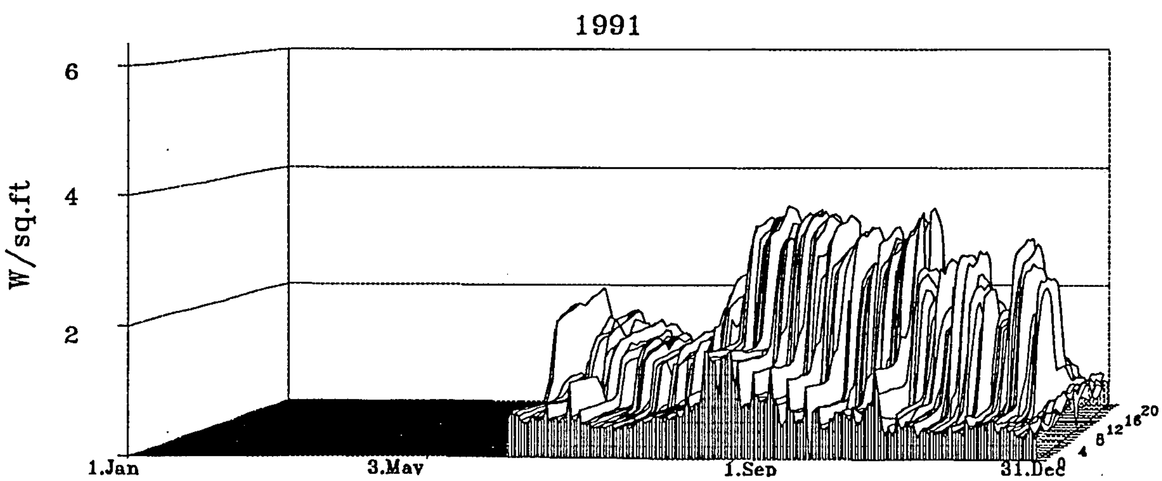
**Date of Retrofits:**

- Replacement of absorption chiller was completed in August 1991, while work on the other retrofit was completed in January 1992.

# Victoria High School (VHS)
# W.B. Electric as W/sq.ft.

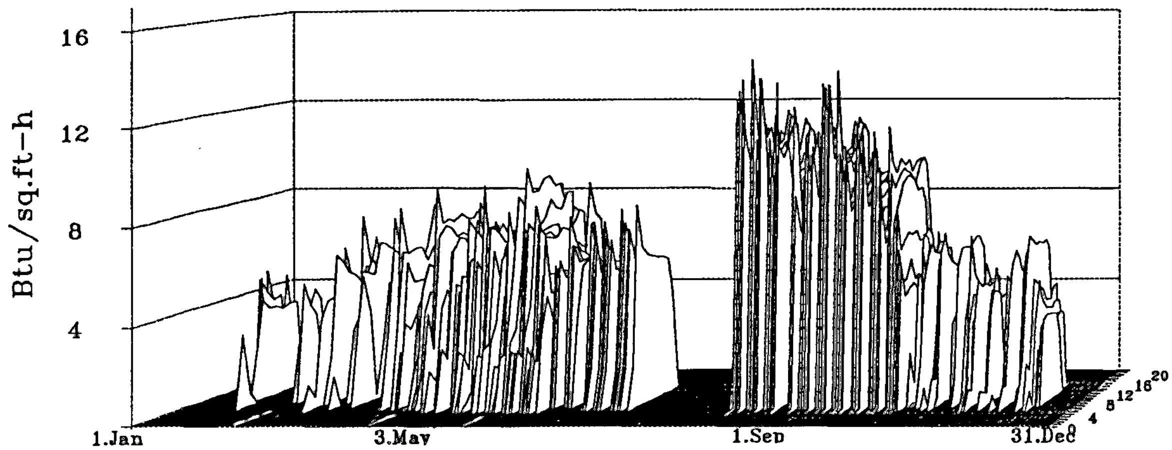


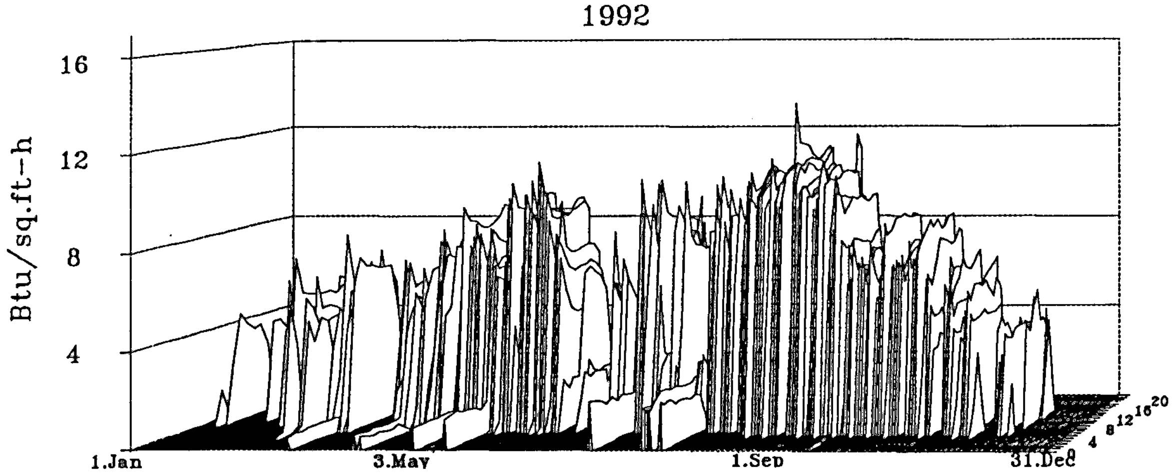



# Victoria High School (VHS)
# W.B. CHW as Btu/sq.ft.-h

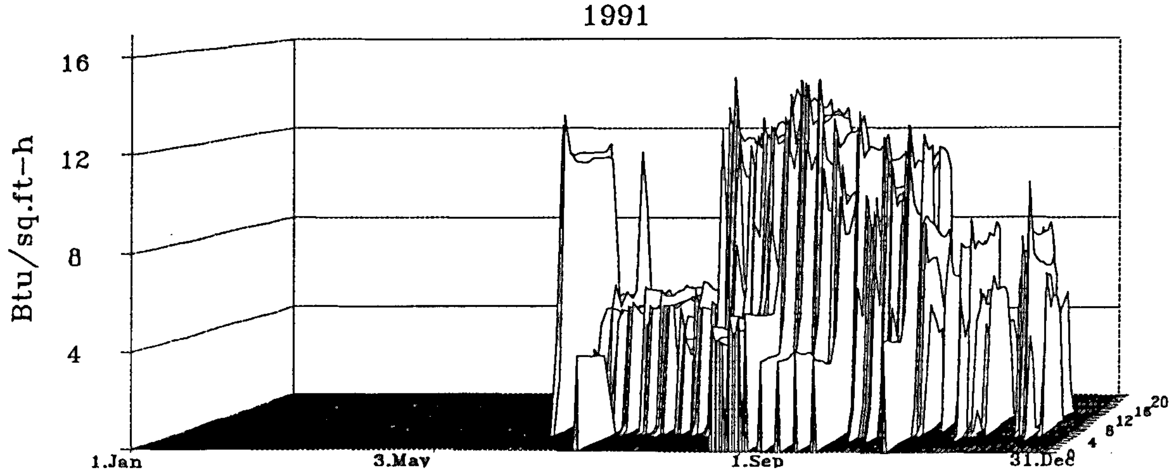
1993




1992

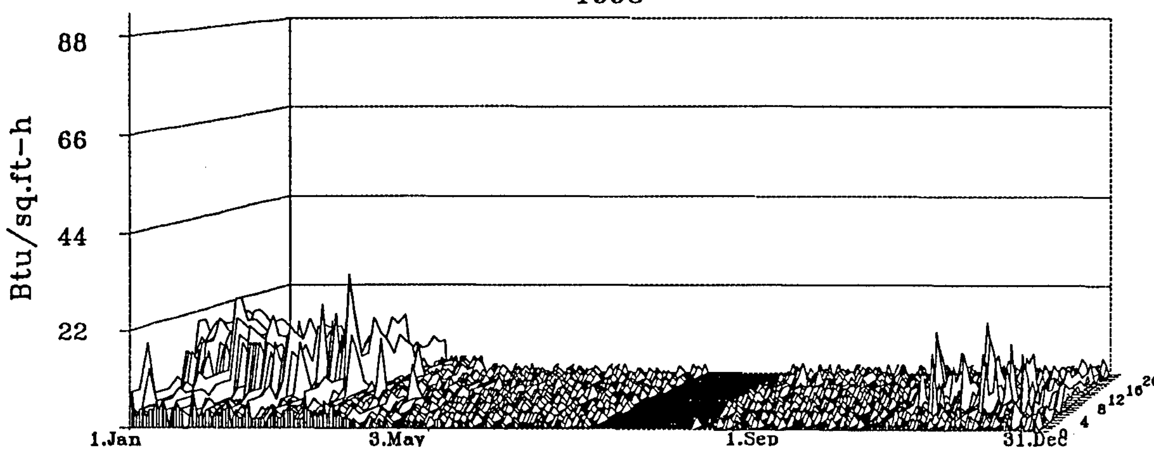



1991

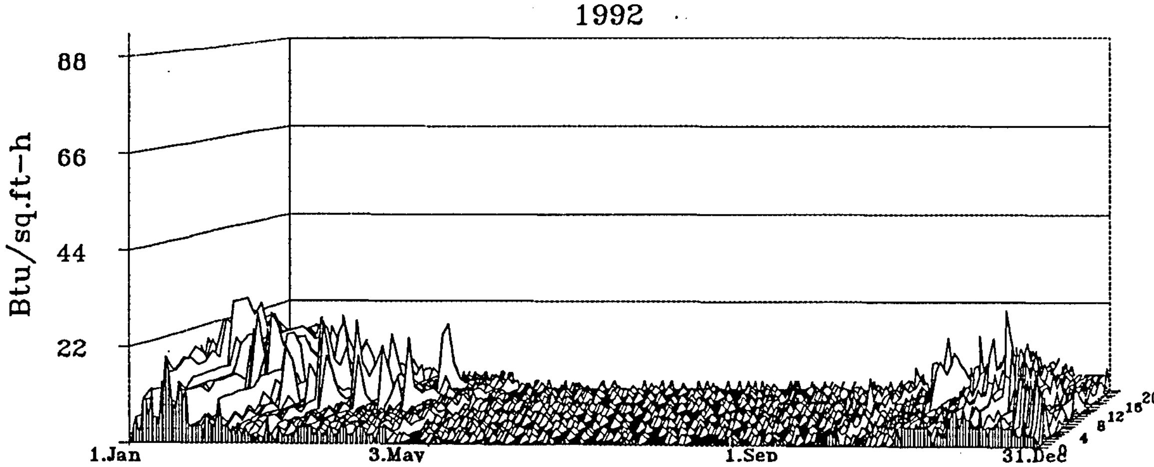


# Victoria High School (VHS)
# W.B. HW as Btu/sq.ft.-h

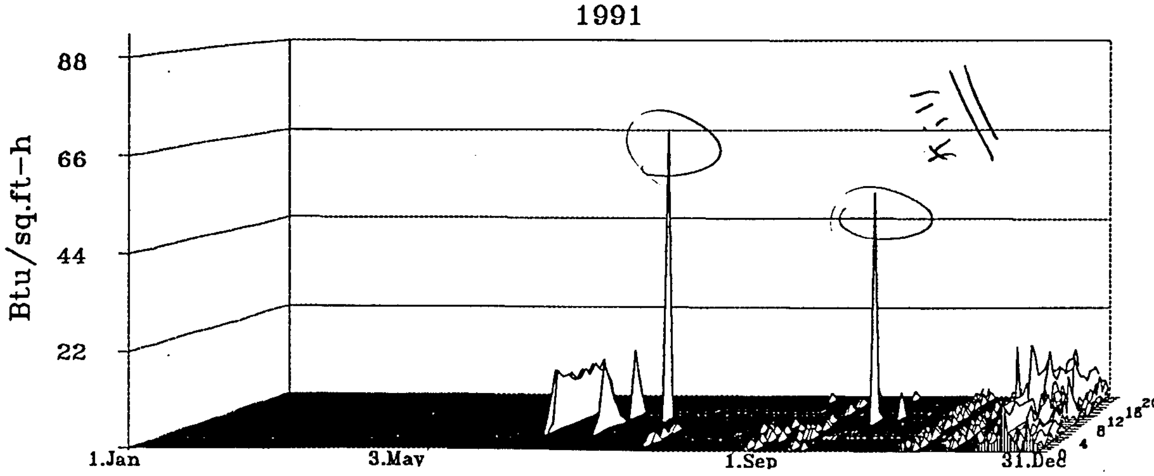
1993



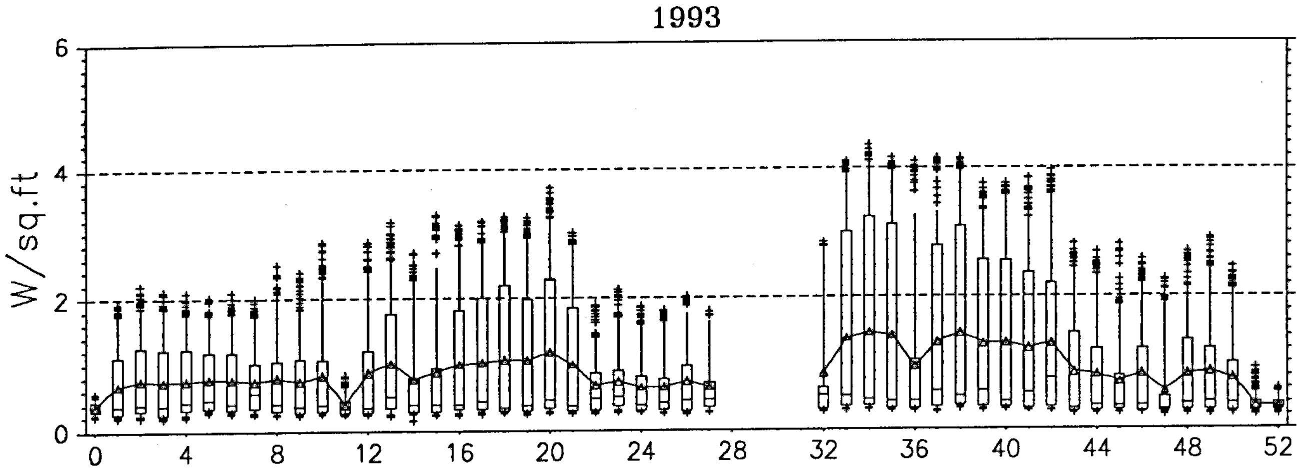

1992

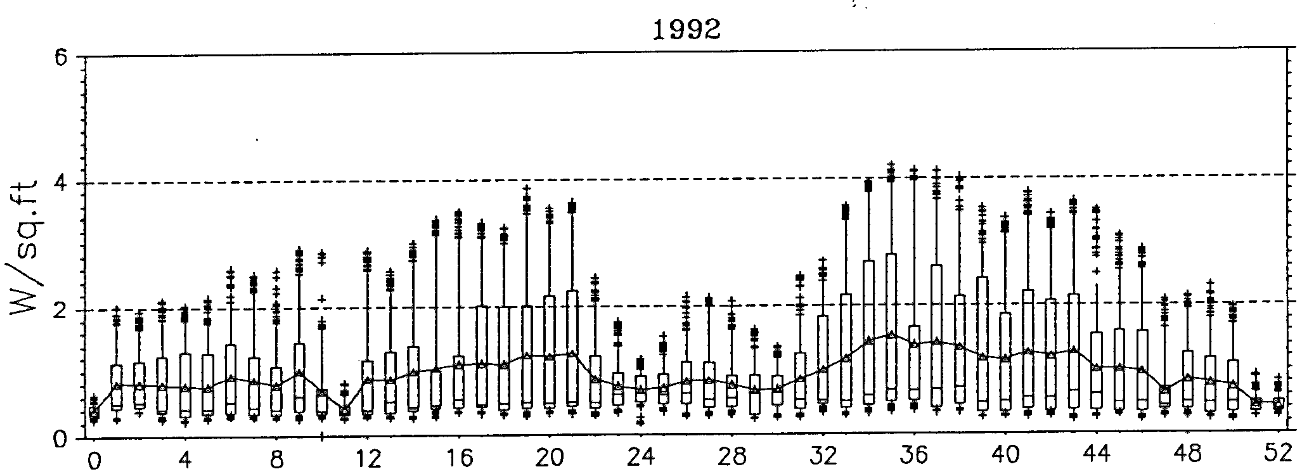


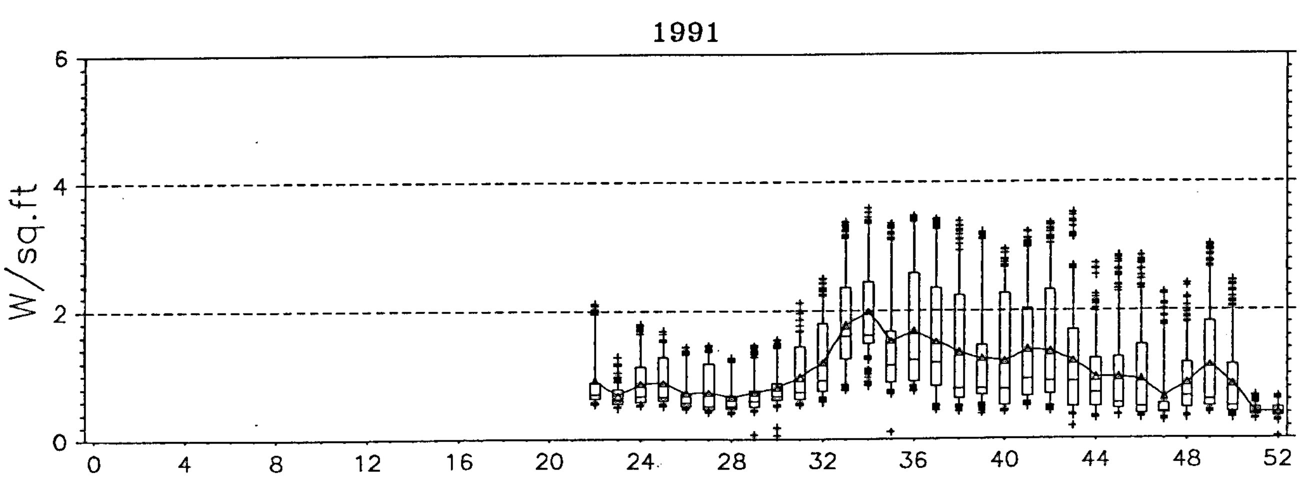

1991



# Victoria High School (VHS)
# W.B. Electric as W/sq.ft.

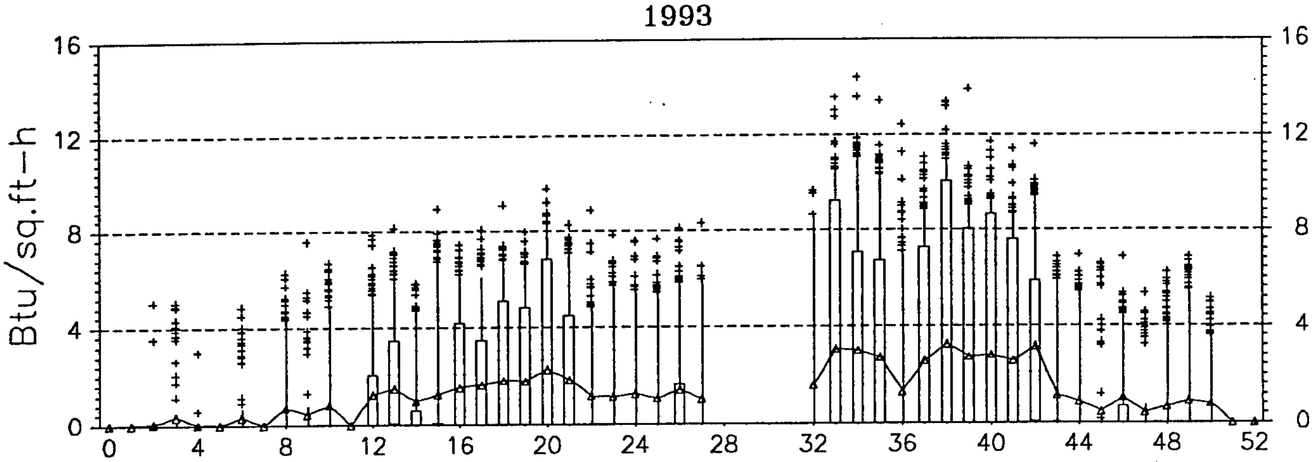


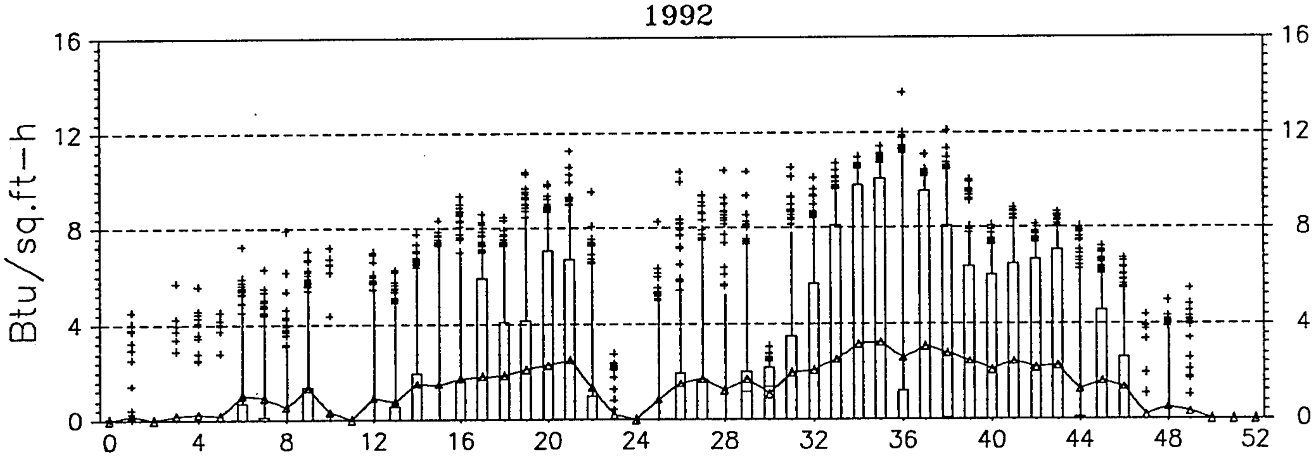



# Victoria High School (VHS)
# W.B. CHW as Btu/sq.ft.-h

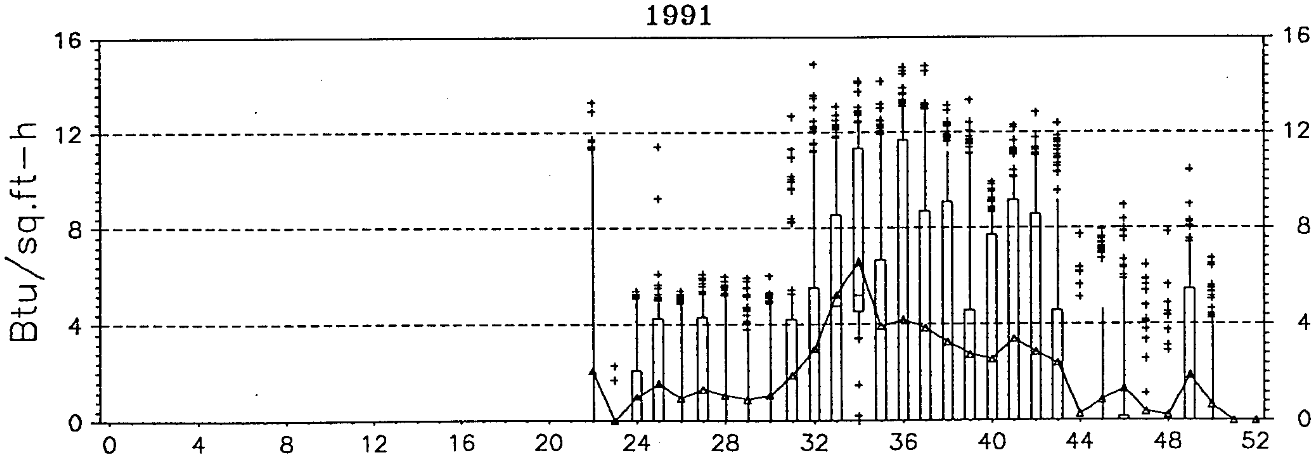
1993



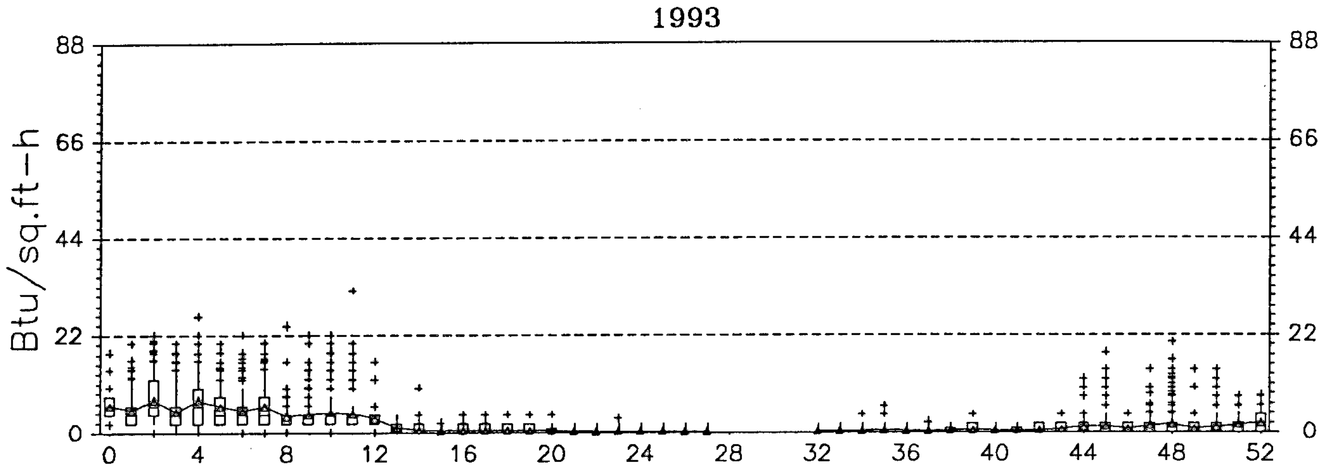

1992

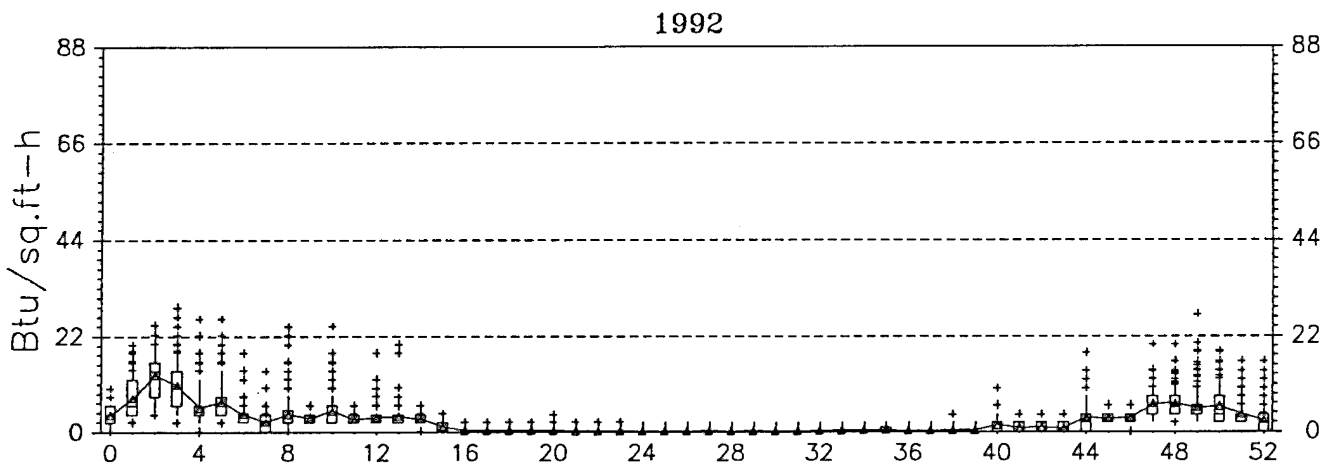


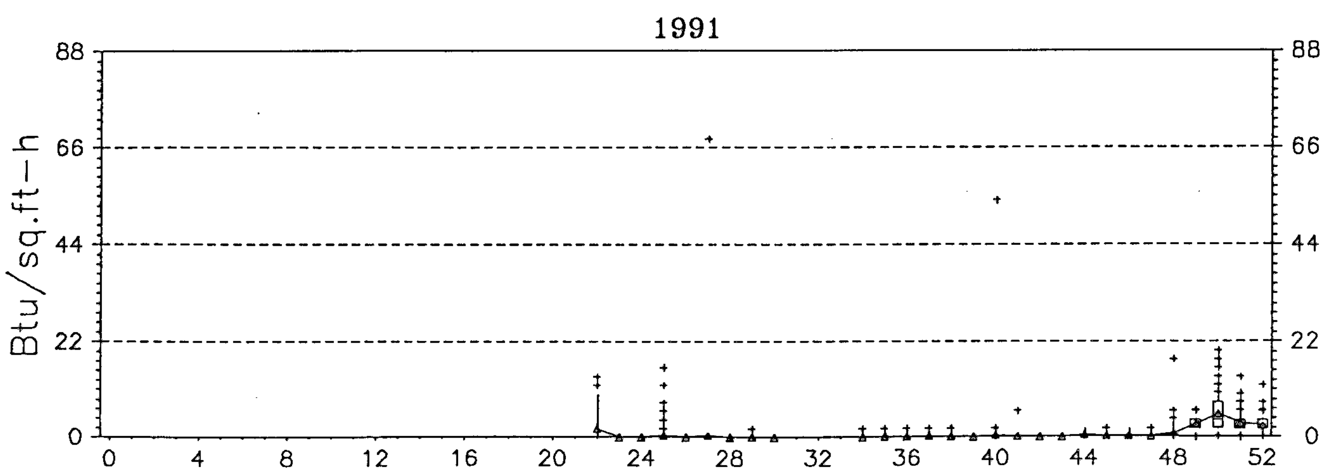

1991



# Victoria High School (VHS)
# W.B. HW as Btu/sq.ft.-h



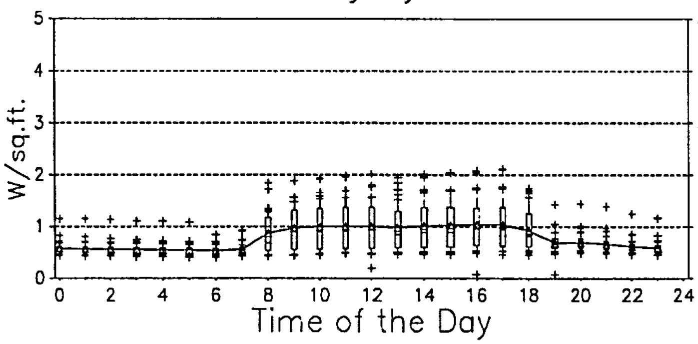



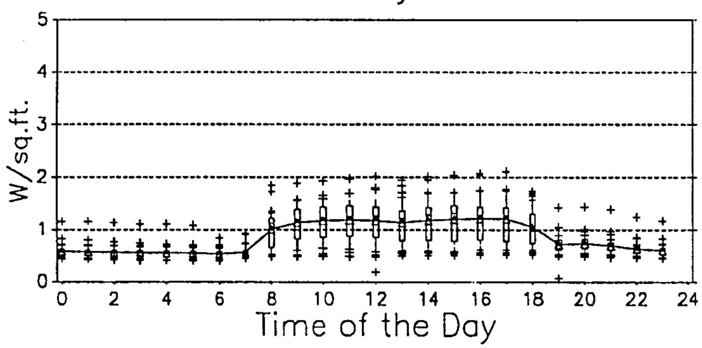
# Victoria High School (VHS)
# W.B. Electric as W/sq.ft.

## Pre-Retrofit (06/04/1991 - 08/01/1991)

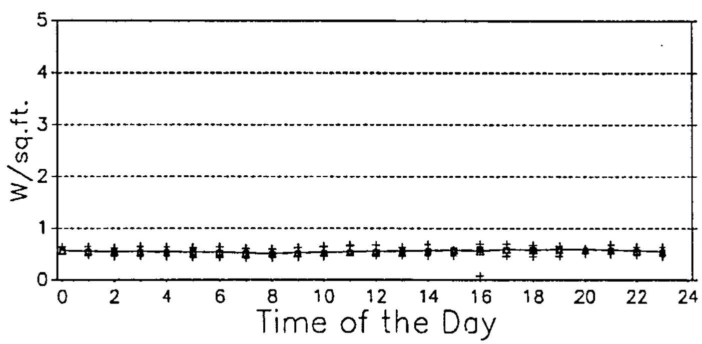
Everyday




Weekdays

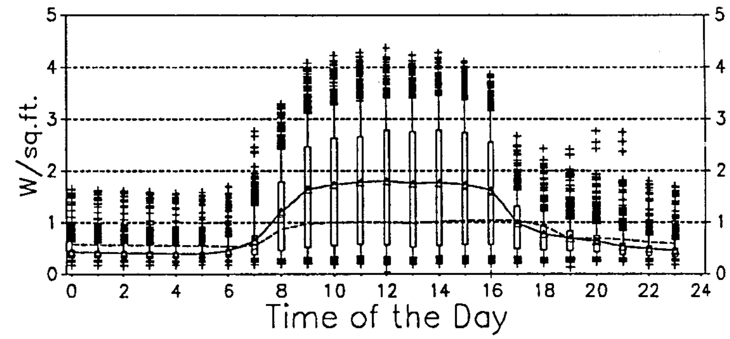



Weekends

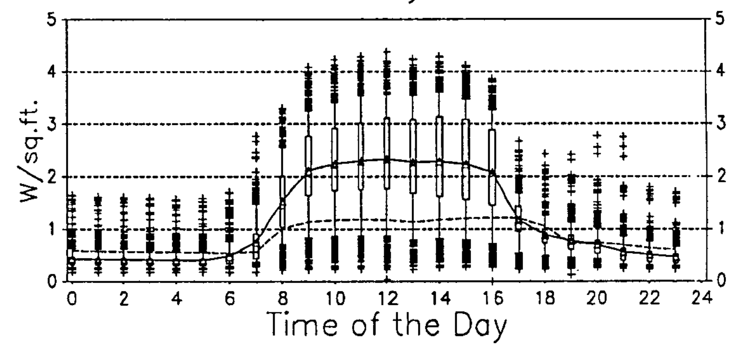



## Post-Retrofit (08/15/1991 - 12/31/1993)

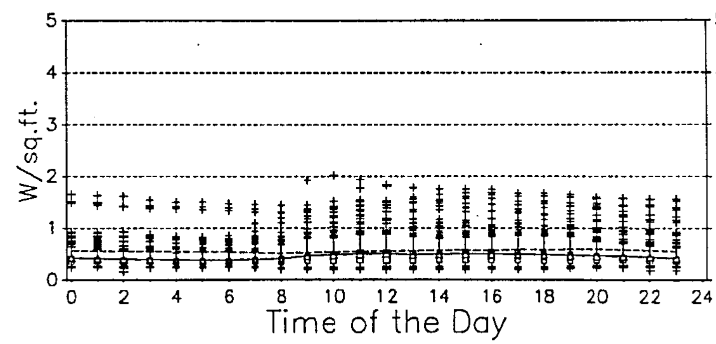
Everyday




Weekdays



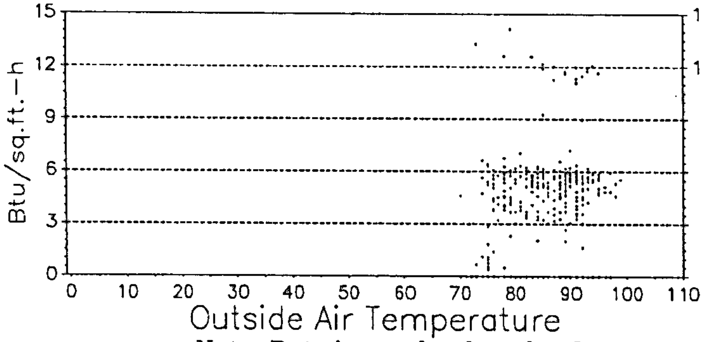

Weekends



# Victoria High School (VHS)
# W.B. CHW as Btu/sq.ft.-h

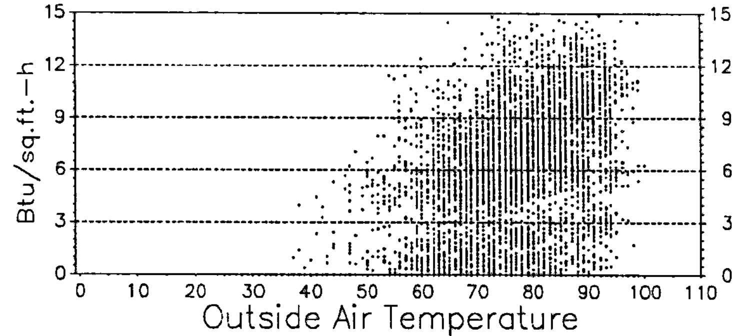
## Pre-Retrofit (06/04/1991 - 08/01/1991)

Everyday



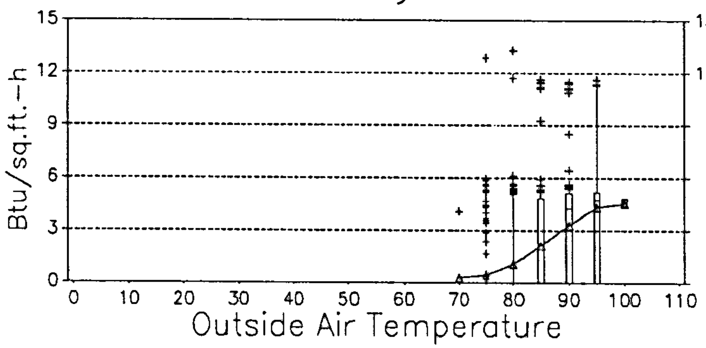

## Post-Retrofit (08/15/1991 - 12/31/1993)

Everyday

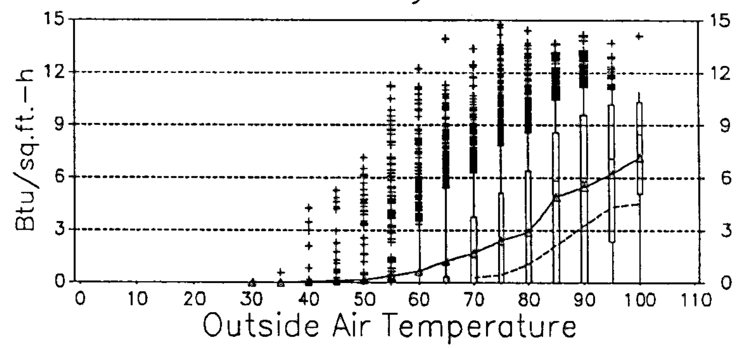



**Note: Data in graphs above has been vertically offset randomly up to 1 Btu/sq.ft.-h to improve graphical presentation.**

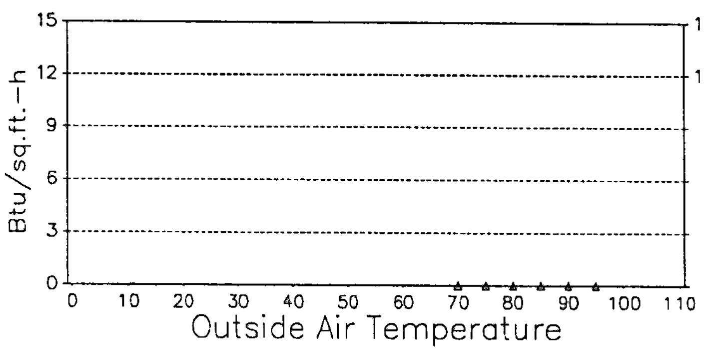
Weekdays



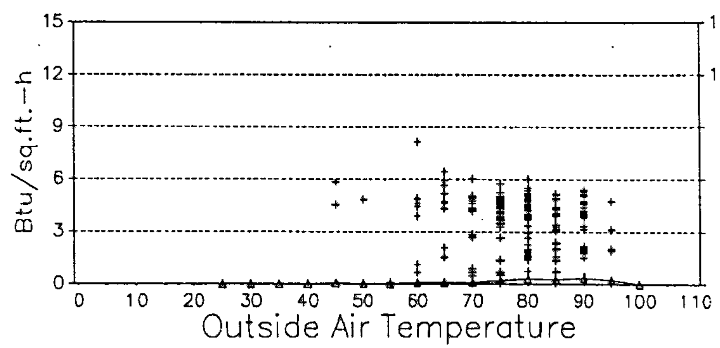

Weekdays




Weekends



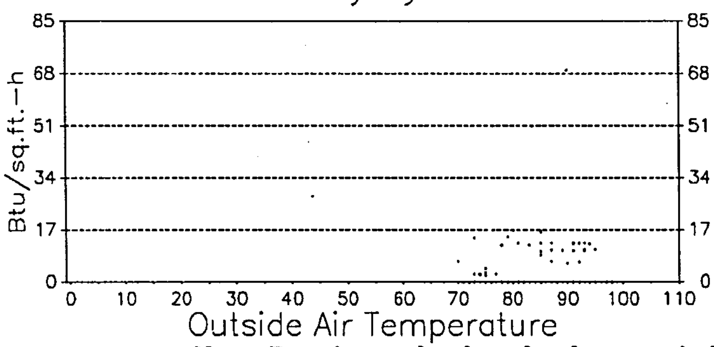

Weekends



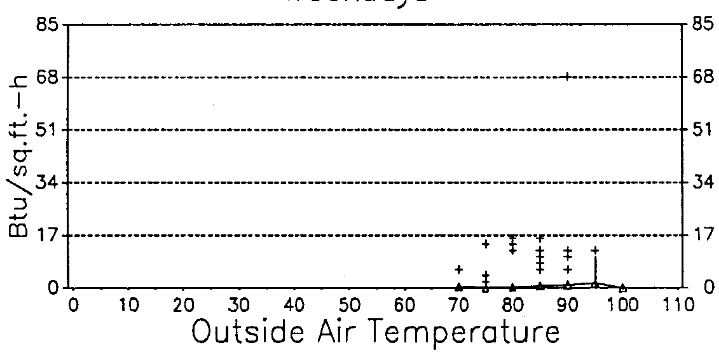
# Victoria High School (VHS)
# W.B. HW as Btu/sq.ft.-h

## Pre-Retrofit (06/04/1991 - 08/01/1991)

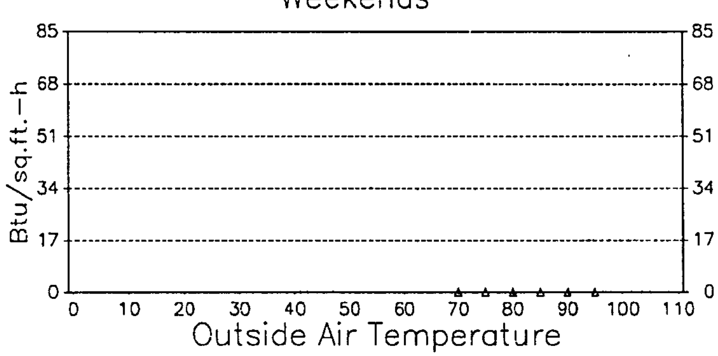
### Everyday




### Weekdays

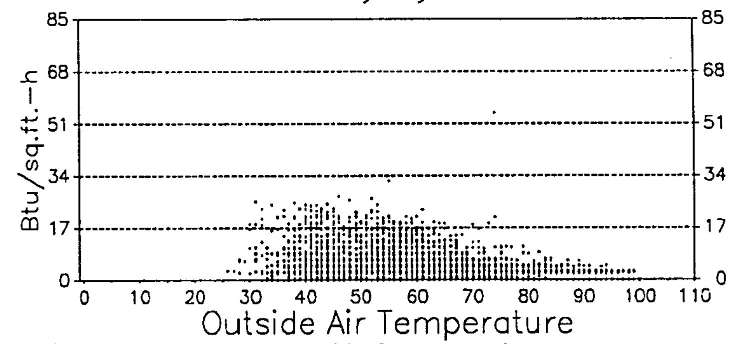



### Weekends



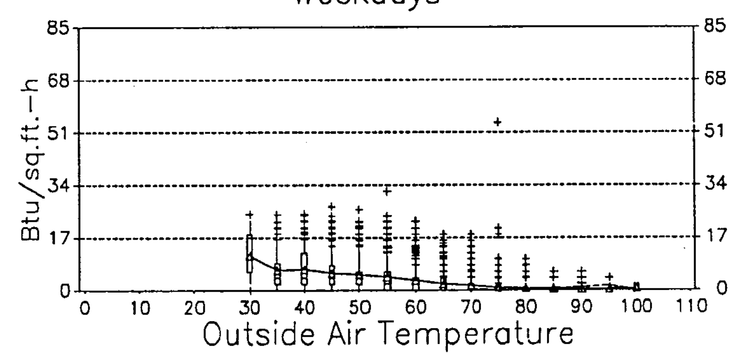

## Post-Retrofit (08/15/1991 - 12/31/1993)

### Everyday

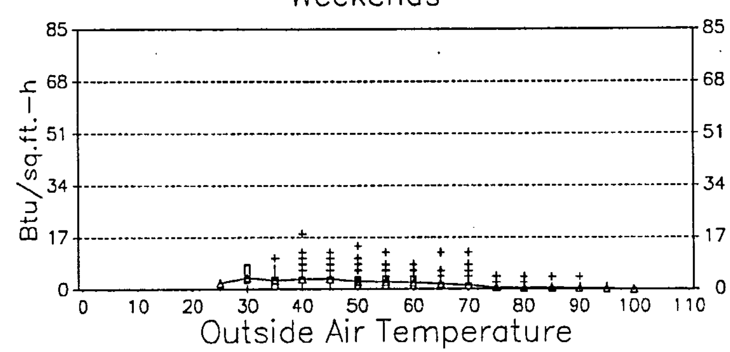



**Note: Data in graphs above has been vertically offset randomly up to 1 Btu/sq.ft.-h to improve graphical presentation.**

### Weekdays

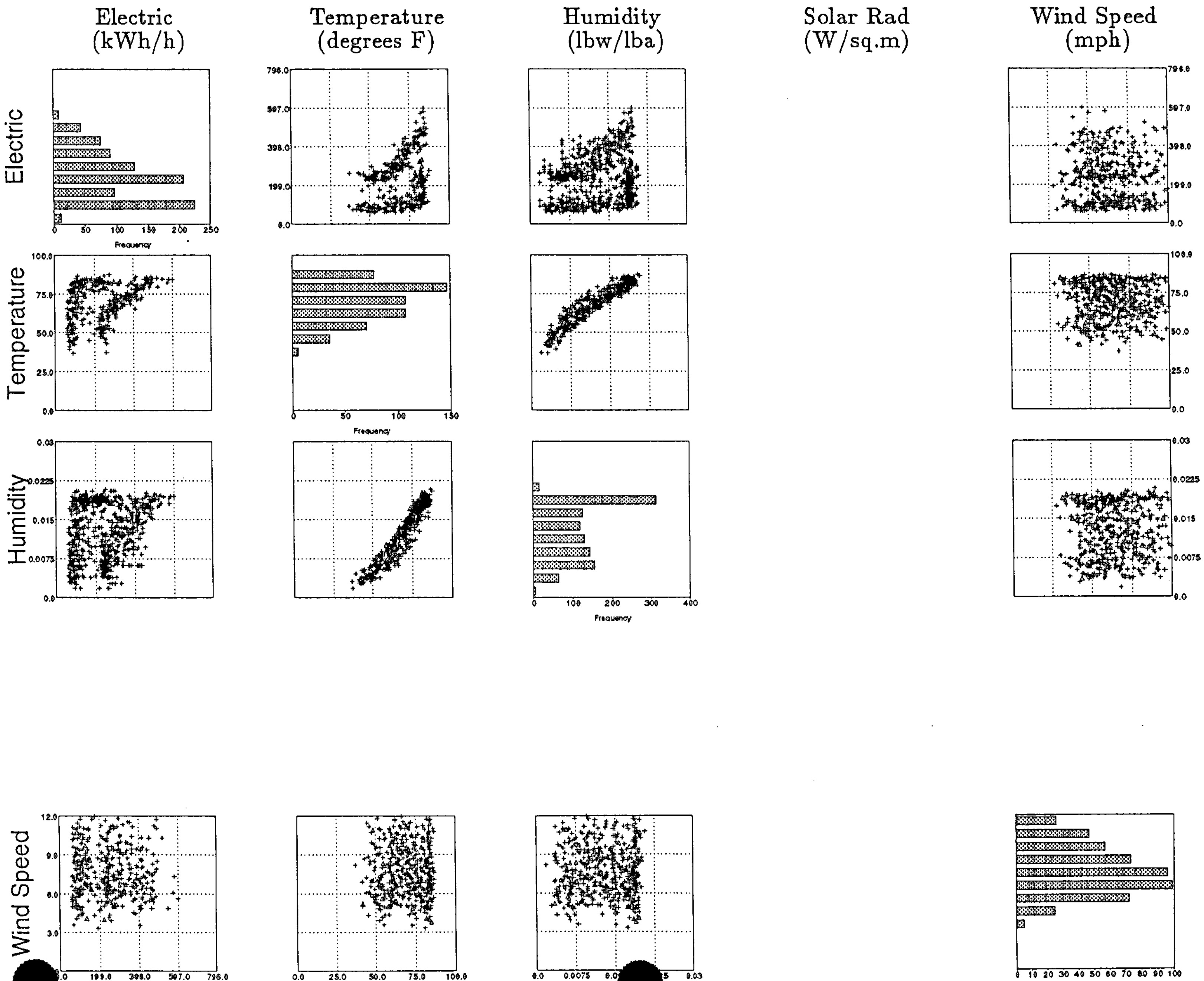



### Weekends



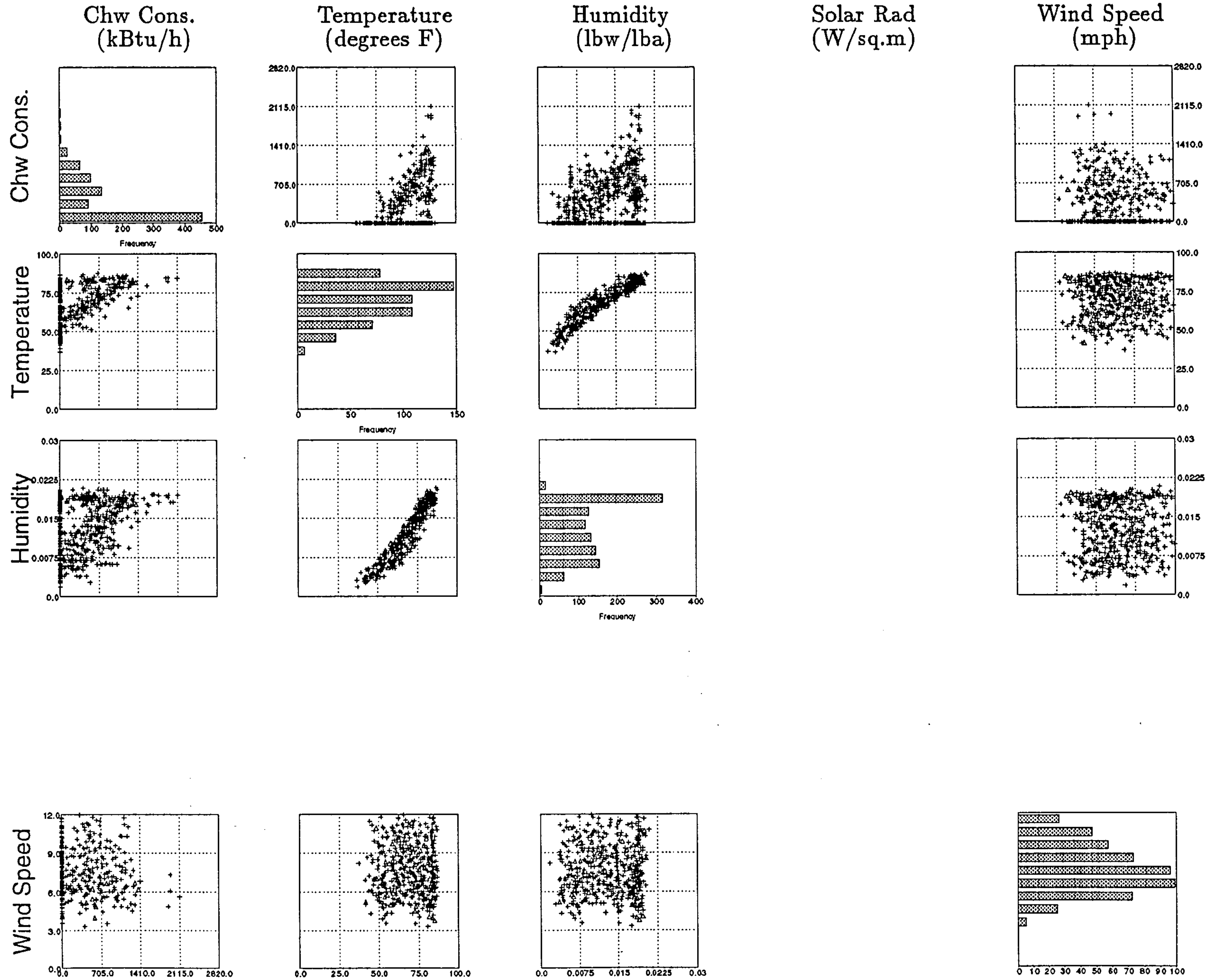
# Victoria High School (VHS)
## Daily Average Values

Pre-Retrofit (Δ) 06/04/1991 - 08/01/1991 Post-Retrofit (+) 08/15/1991 - 12/31/1993



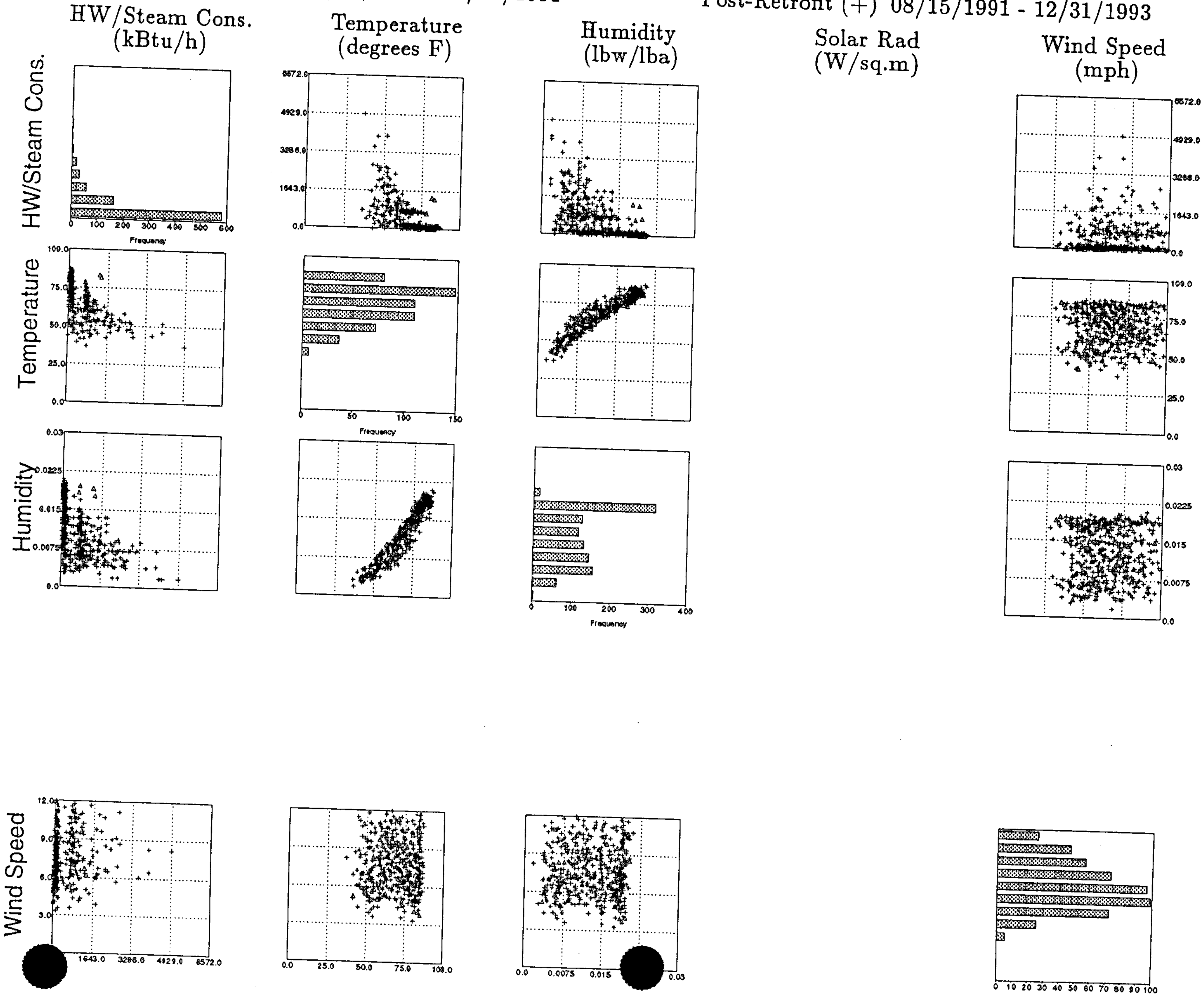
# Victoria High School (VHS)
## Daily Average Values

Pre-Retrofit (△) 06/04/1991 - 08/01/1991 Post-Retrofit (+) 08/15/1991 - 12/31/1993



# Victoria High School (VHS)
## Daily Average Values

Pre-Retrofit (△) 06/04/1991 - 08/01/1991 Post-Retrofit (+) 08/15/1991 - 12/31/1993



# C. SIMS ELEMENTARY SCHOOL

## *C.1 Site Description*[1]

Sims Elementary School is located in Fort Worth, Texas. It is a 62,400 square foot, single story, concrete building with single pane, tinted, operable windows.

The school is operated from August through May, with approximately 862 students and 50 faculty and staff. The maximum school occupancy is from about 7:00 a.m. through 3:00 p.m. The building has a lower occupancy during the weekend. There are also three summer sessions of three weeks duration each, during the morning in the summertime, with only about 10% of the students and staff present. The school district schedule is included under Tab C-1.

Electricity is purchased from Texas Utilities Electric Company, and natural gas from Lone Star Gas Company.

## *C.2 EMCS Retrofit*

As part of monitoring done for other retrofits at this site and Dunbar Middle School, it was decided to fine tune the existing EMCS at Dunbar Middle School. This was done as an operation and maintenance (O&M) project; separate from the other retrofits. This was a success at Dunbar Middle School. Meanwhile, a private company approached the school district, proposing the installation of a new EMCS. The school district purchased and installed a new EMCS at Sims Elementary School. The new system was operable on April 14, 1991, and has a few more capabilities than the existing system. The LoanSTAR staff at Texas A&M University pointed out to the school district that their existing EMCS was able to control the majority of their equipment, and if fine tuned, would operate well for them. Based on an economic analysis, it was recommended that they fine tune their existing systems instead of buying new systems for other schools within the district.

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[1] Adapted from: Landman, D.S., 1995. "Preliminary Study of Advanced Diagnostic Prescreening Methods," Energy Systems Laboratory, Mechanical Engineering Department, Texas A&M University, College Station, TX.

## *C.3 Analysis*

### C.3.1 Snapshot of consumption for September 1991 through December 1993

Figures C-1 and C-2 represent monthly average consumption and peak consumption versus min-max average (or peak) monthly temperature.[2] Min-max average monthly temperature is calculated by averaging the maximum and minimum temperature each day to obtain min-max average daily temperature. The daily temperatures are then averaged over all days in each month to obtain min-max average monthly temperature.

The data points reflecting high temperature and low consumption are indicative of non-semester consumption. If those data points are ignored, there is a general increase of consumption with temperature, indicating a temperature dependence of consumption. Additionally, the post-retrofit data points are generally lower than the pre-retrofit data points. When compared to similar plots for other Texas schools in the LoanSTAR program, this site is a high energy use school. The reader is referred to the referenced report for a more detailed discussion of these plots.

[2] Landman, D.S., 1995. "Preliminary Study of Advanced Diagnostic Prescreening Methods," Energy Systems Laboratory, Mechanical Engineering Department, Texas A&M University, College Station, TX.

**Figure C-1:** ***Monthly Average Consumption:*** **Demand, in W/sf, versus min-max average monthly temperature, in °F, for September 1991 through December 1993 (Sims Elementary School)**

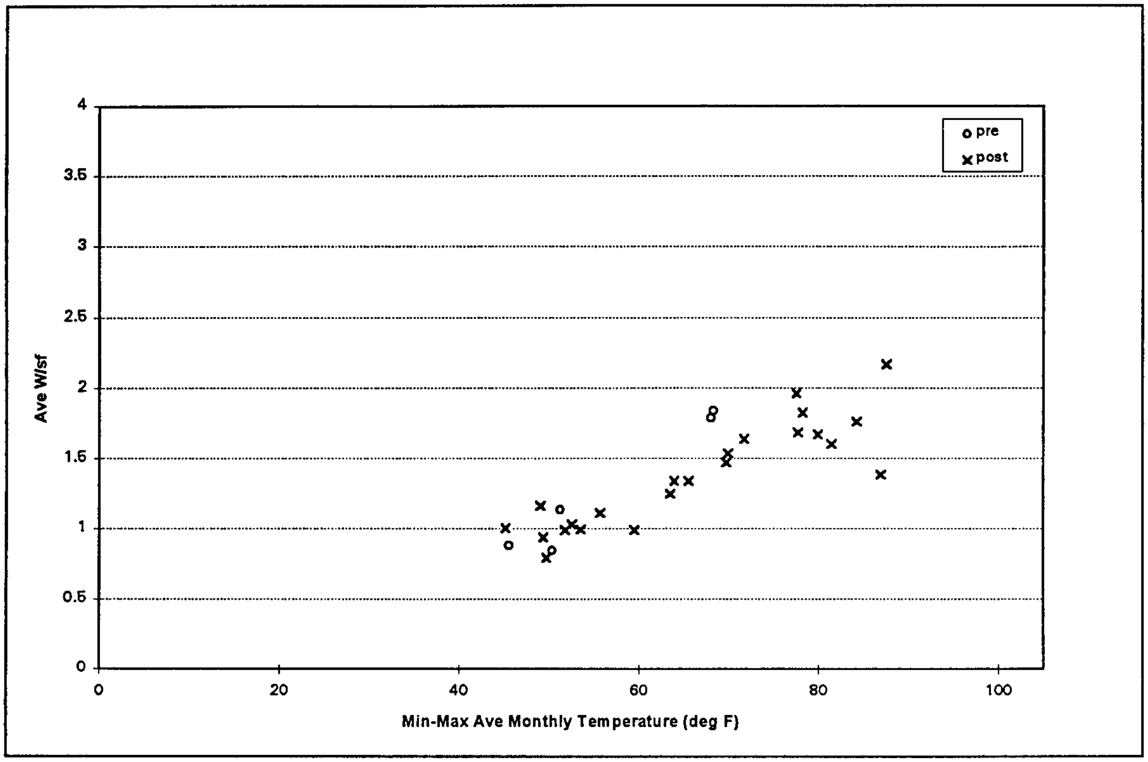
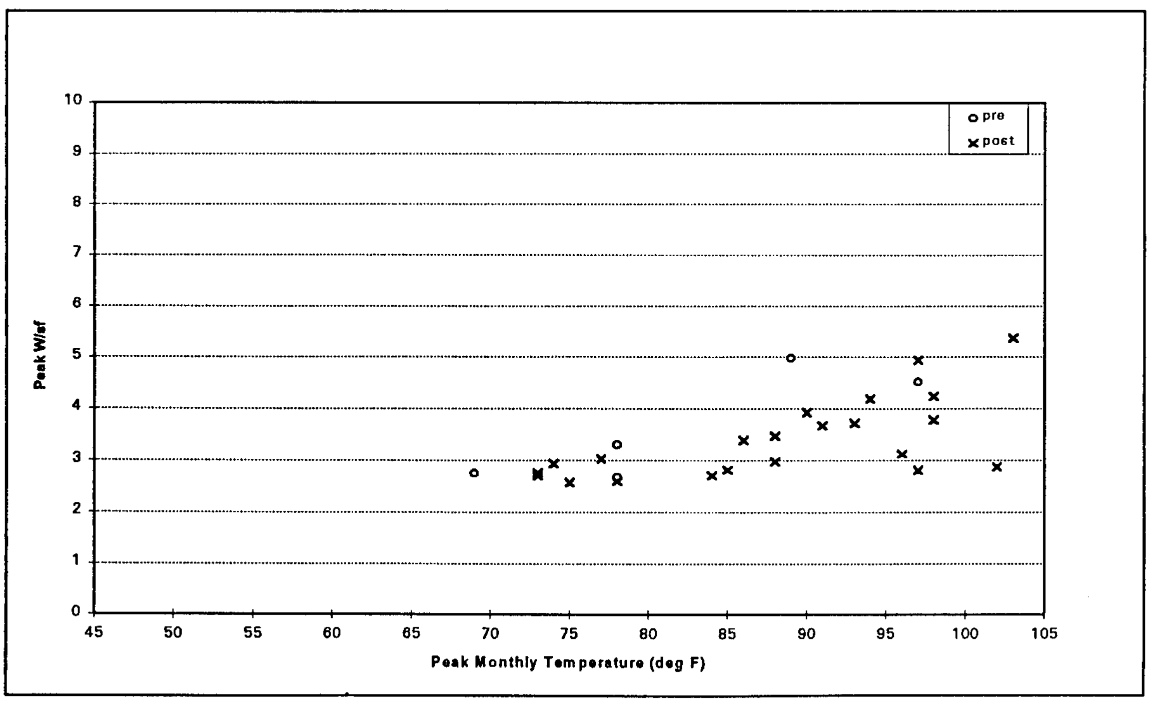



**Figure C-2:** ***Monthly Peak Consumption:*** **Demand, in W/sf, versus peak monthly temperature, in °F, for September 1991 through December 1993 (Sims Elementary School)**

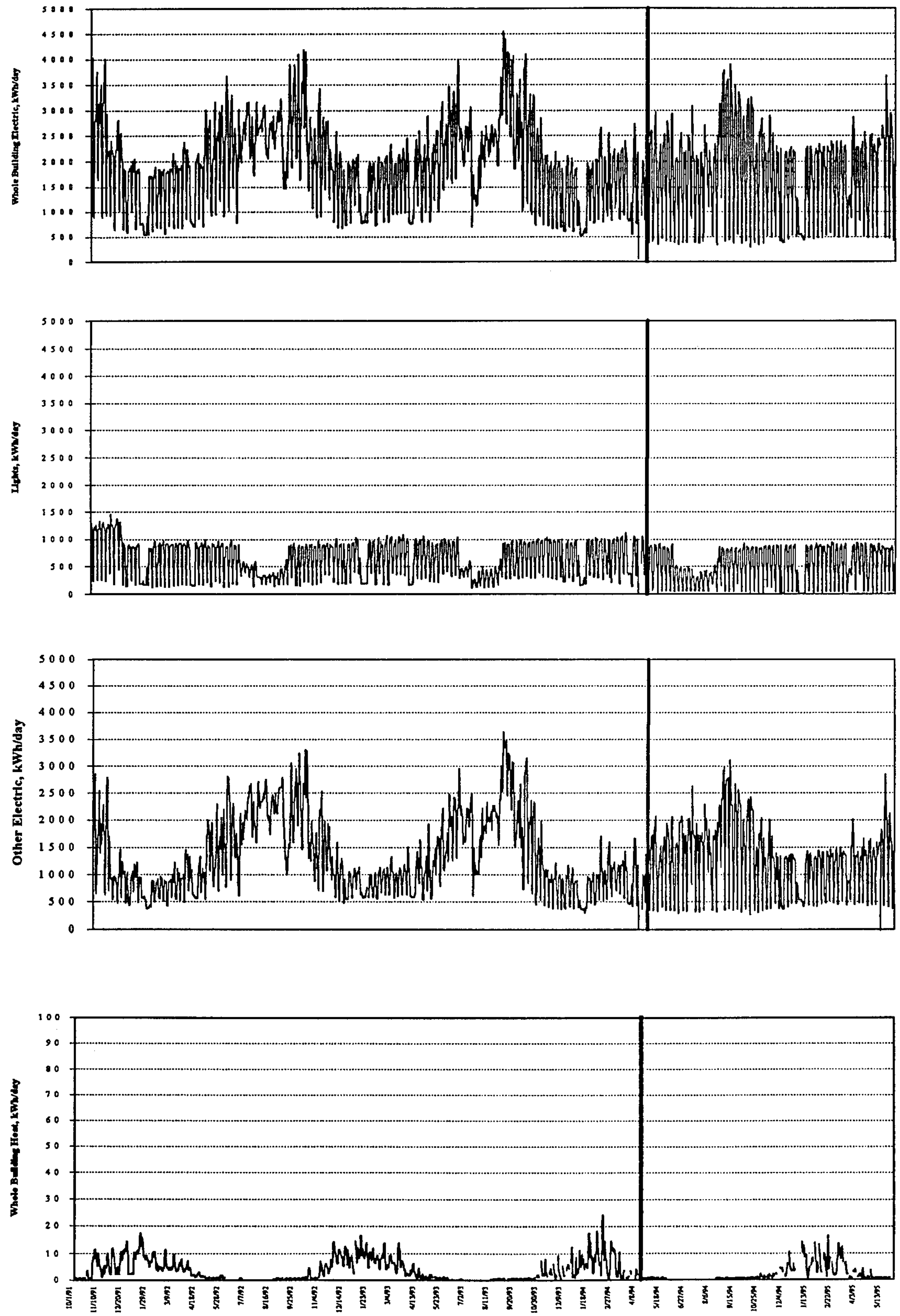


### C.3.2 Timeline plots

Plots of energy consumption for the reporting period of October 1, 1991, through May 31, 1995, are shown in Figure C-3. The EMCS retrofit date of April 14, 1994, is shown by a vertical, bold line. Monitoring diagrams are provided in Tab C-2.

In looking at the whole building electric plot, there is no apparent decrease in consumption at any point along the timeline. The monitoring of electricity consumption at this site includes separate channels for whole building electric and lights. The EMCS does not control the lights, so they were subtracted from whole building electric to obtain other electric. This category consists of HVAC equipment, mostly roof top A/C units. The timeline of other electric shows a definite pattern between October 1, 1991, and April 14, 1994, the retrofit date. After the retrofit date, the consumption actually appears to increase. If the months surrounding February are analyzed for each year on the plot, one can see an increase from approximately 1,000 kWh/day to 1,500 kWh/day. The plot of whole building heat shows seasonal heating between November and April of each year.

**Figure C-3:** ***Energy Consumption:*** **time series for October 1991 to May 1995 (Sims Elementary School)**



### C.3.3 Whole Building Electricity Consumption (Post-Retrofit Period)

Table C-1 shows energy consumption for the post-retrofit period (April 14, 1994, through May 31, 1995). Whole building electricity consumption is broken down into two components: lighting consumption and other electricity consumption. It is further subdivided into semester period and non-semester periods. The post-retrofit period is used because there is significantly more data available in the post-retrofit period, and it represents current usage.

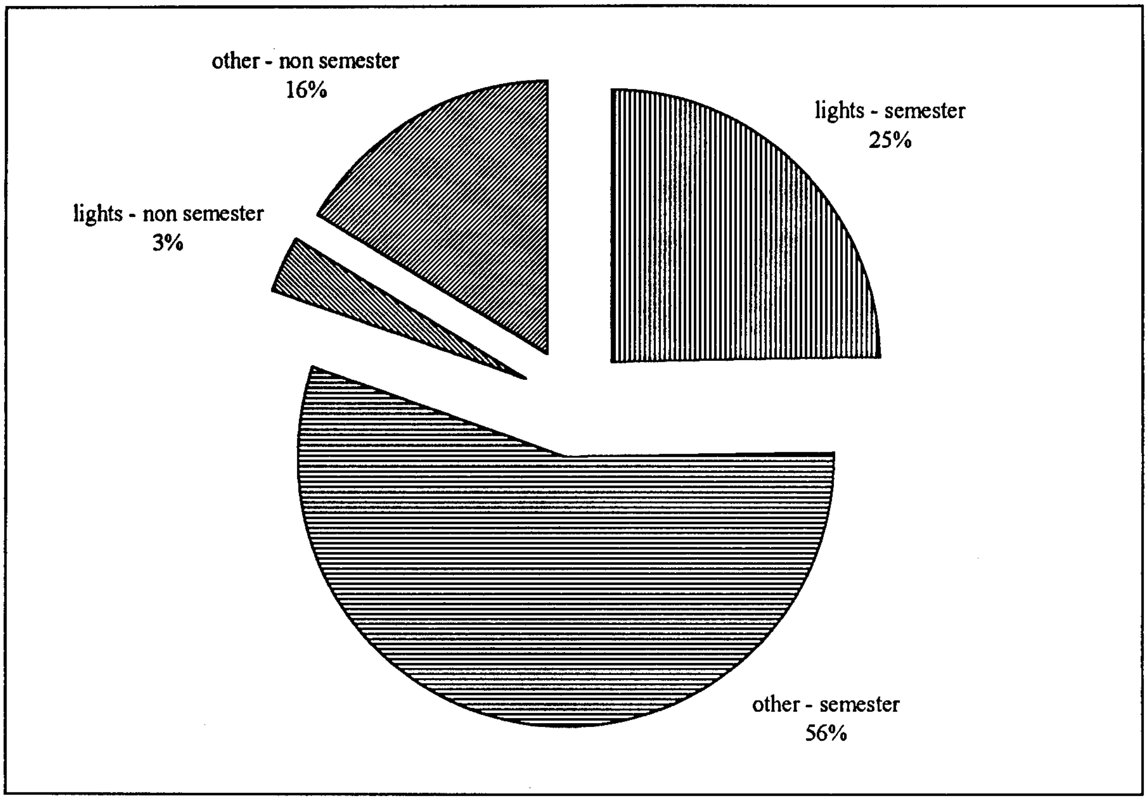
Figure C-4 graphically shows whole building electricity consumption for the post-retrofit period. For the semester period, 55% of whole building electric energy use is attributable to other electric equipment, while 26% is due to the lights. For the non-semester period, other electric accounts for 15% of whole building electric energy, while the lights account for 4%.

From both Table C-1 and Figure C-4, it is readily apparent that lighting accounts for a small portion of the whole building electricity usage. Therefore, attention for reducing energy usage should be focused on the other electricity usage. In this case, other electricity consumption is mainly roof-top HVAC units.

**Table C-1:** ***Energy Consumption*** **for post period, October 1991 through May 1995 (Sims Elementary School)**

| | SEMESTER | | NON-SEMESTER | | TOTAL | |
|---|---|---|---|---|---|---|
| | ENERGY | $ | ENERGY | $ | ENERGY | $ |
| wbelec, kWh | 605,715 | $40,825 | 142,510 | $9,605 | 748,225 | $50,430 |
| lights, kWh | 196,445 | $13,240 | 27,258 | $1,837 | 223,703 | $15,078 |
| other, kWh | 409,270 | $27,585 | 115,251 | $7,768 | 524,521 | $35,353 |
| wbheat, MMBtu | 588 | $2,705 | 49 | $225 | 637 | $2,930 |

**Figure C-4:** ***Whole Building Electricity Consumption*** **for post period, April 15, 1994, through May 1995 (Sims Elementary School)**




## C.3.4 Total Monthly Consumption

The total monthly energy consumption is summarized in Table C-2. Again, it is readily apparent that other electric accounts for the majority of this site's electric energy use.

Table C-2: *Monthly Energy Consumption* (Sims Elementary School)

| | wbelec kWh/month | lights kWh/month | other kWh/month | wbheat MMBtu/month |
|---|---|---|---|---|
| PRE-RETROFIT PERIOD | | | | |
| Oct 91 | 83,200 | 30,111 | 52,767 | 94 |
| Nov | 50,829 | 25,299 | 30,443 | 194 |
| Dec | 39,223 | 15,934 | 28,111 | 254 |
| Jan 92 | 40,865 | 19,072 | 39,175 | 158 |
| Feb | 43,217 | 19,463 | 53,383 | 36 |
| Mar | 45,896 | 17,250 | 64,549 | 14 |
| Apr | 60,103 | 20,321 | 60,523 | 25 |
| May | 71,339 | 20,348 | 37,712 | 126 |
| Jun | 75,790 | 14,853 | 30,594 | 301 |
| Jul | 82,092 | 9,536 | 34,582 | 202 |
| Aug | 77,690 | 13,810 | 42,819 | 66 |
| Sep | 88,241 | 19,932 | 68,998 | 19 |
| Oct | 68,149 | 21,649 | 76,339 | 18 |
| Nov | 46,415 | 19,362 | 37,985 | 62 |
| Dec | 42,766 | 17,975 | 28,563 | 156 |
| Jan 93 | 46,702 | 20,424 | 34,678 | 325 |
| Feb | 47,163 | 21,440 | 29,892 | 62 |
| Mar | 51,509 | 20,818 | 48,753 | 208 |
| Apr | 56,023 | 21,790 | 71,657 | 48 |
| May | 76,217 | 23,457 | 55,507 | 82 |
| Jun | 72,174 | 13,640 | 39,562 | 177 |
| Jul | 64,380 | 9,258 | 39,837 | 1 |
| Aug | 100,835 | 18,188 | 43,885 | 123 |
| Sep | 82,136 | 21,994 | 44,956 | 119 |
| Oct | 62,260 | 23,622 | 35,769 | 2 |
| Nov | 44,385 | 21,773 | 19,656 | 147 |
| Dec | 36,881 | 17,399 | 42,318 | 2 |
| Jan 94 | 47,920 | 22,462 | 20,807 | 77 |
| Feb | 47,822 | 21,114 | 34,312 | 68 |
| Mar | 47,045 | 20,615 | 22,858 | 118 |
| Apr (partial) | 17,300 | 8,329 | 7,468 | 12 |
| Total Consumption | 1,816,566 | 591,236 | 1,278,455 | 3,294 |
| Total Cost | $122,437 | $39,849 | $86,168 | $15,151 |

**post-retrofit period and grand total shown on next page

Table C-5 (continuation): *Monthly Energy Consumption* (Sims Elementary School)

| | wbelec kWh/month | lights kWh/month | other kWh/month | wbheat MMBtu/month |
|---|---|---|---|---|
| POST PERIOD | | | | |
| Apr (partial) | 32,096 | 11,077 | 6,693 | 13 |
| May | 55,455 | 18,115 | 12,136 | 12 |
| Jun | 53,858 | 10,086 | 15,211 | 18 |
| Jul | 49,640 | 8,130 | 14,564 | 33 |
| Aug | 76,882 | 17,289 | 60,594 | 152 |
| Sep | 69,274 | 18,626 | 53,163 | 215 |
| Oct | 58,523 | 18,894 | 42,543 | 102 |
| Nov | 47,199 | 16,682 | 55,783 | 20 |
| Dec | 37,715 | 11,858 | 37,564 | 1 |
| Jan 95 | 51,821 | 18,954 | 53,586 | 13 |
| Feb | 48,218 | 17,560 | 17,931 | 10 |
| Mar | 54,202 | 19,076 | 46,095 | 1 |
| Apr | 52,034 | 18,638 | 37,498 | 46 |
| May | 61,310 | 18,720 | 18,036 | 2 |
| Total Consumption | 748,224 | 223,703 | 471,396 | 637 |
| Total Cost | $50,430 | $15,078 | $31,772 | $2,930 |

| | | | | |
|---|---|---|---|---|
| Grand Total Consumption | 2,564,791 | 814,939 | 1,749,852 | 3,931 |
| Grand Total Cost | $172,867 | $54,927 | $117,940 | $18,081 |

## C.3.5 Average Daily Consumption

Figures C-5a and C-5b depict the average daily consumption for the semester period and the non-semester period.

For the semester period (Figure C-5a) the weekday consumption greatly increased during the daytime hours (7:00 a.m. to 6:00 p.m.), and significantly decreased during the nighttime hours (6:00 p.m. to 7:00 a.m.) Although the daytime consumption increased, the profile is as expected, with the startup of an EMCS. The nighttime consumption is low, with a sharp increase to daytime levels at 7:00 a.m. At the end of the day, there is a sharp decrease in consumption, indicating that the EMCS has shut off the equipment. The reason for daytime consumption increasing has not been determined for the purposes of this report. It could be due to a number of factors, such as: installation of new equipment, repair of existing equipment that was down during the pre-retrofit period, or erroneous data.

**Figure C-5a:** *Semester Pre-/Post-Retrofit Comparison:* **based on average hourly data (Sims Elementary School)**

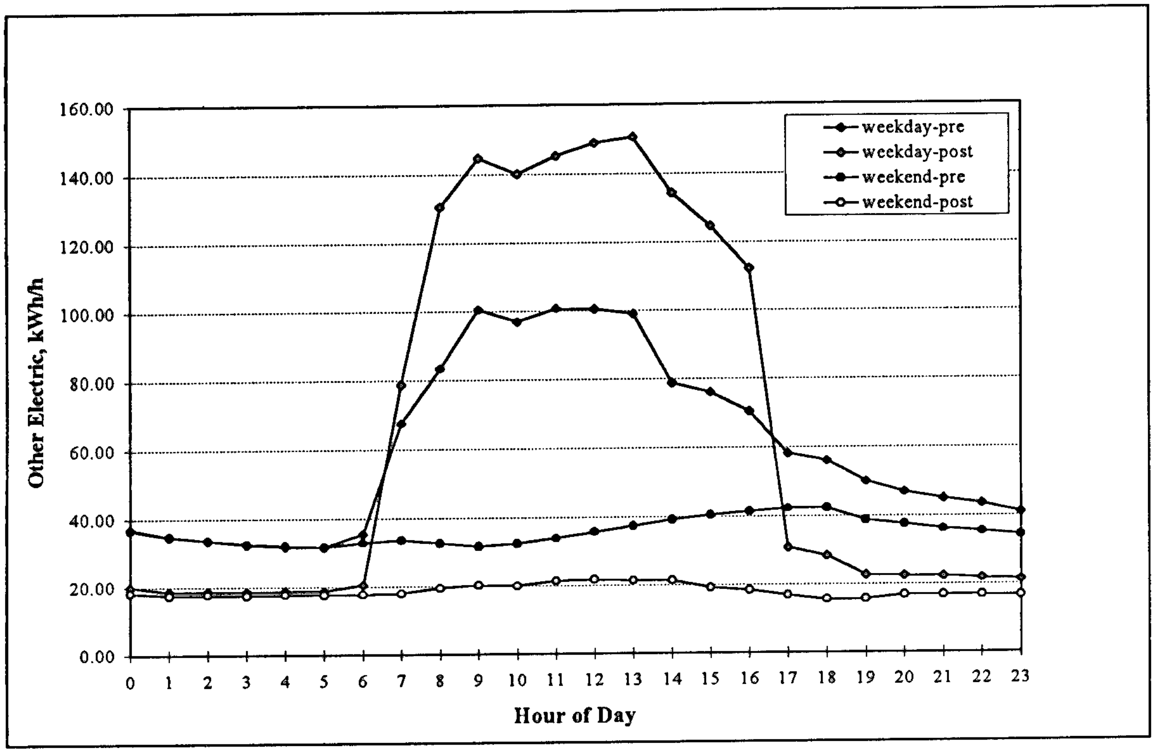
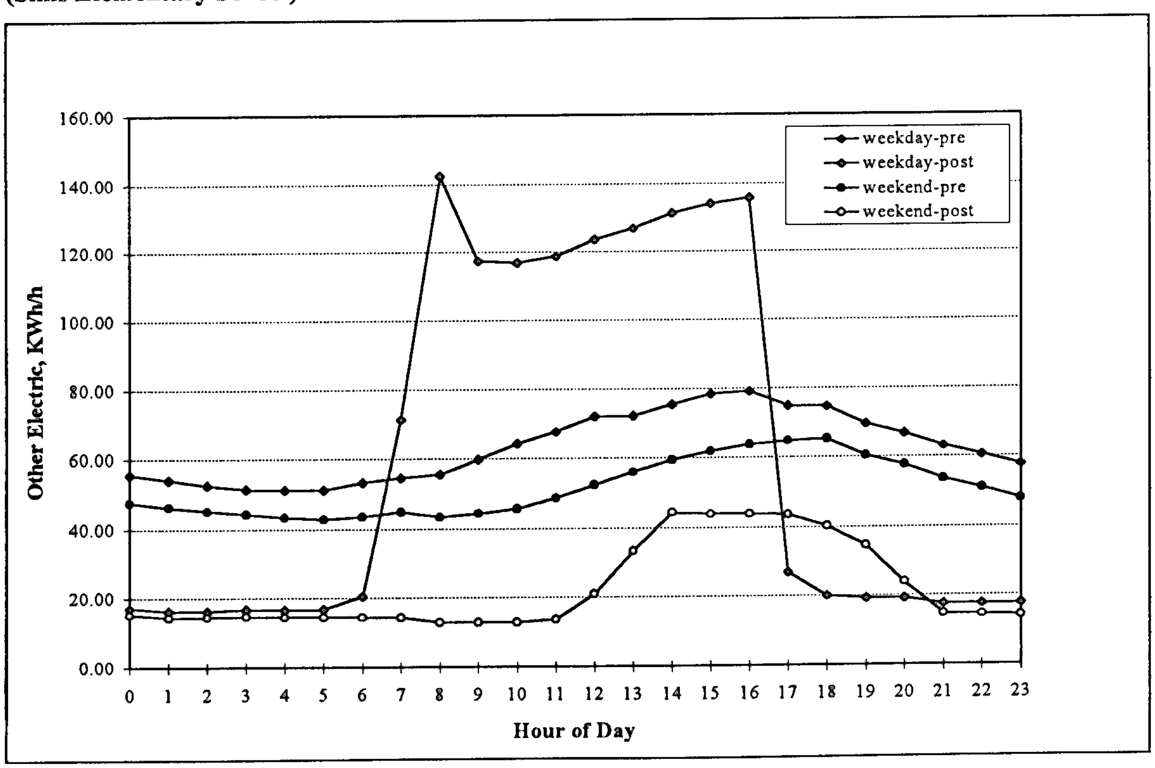



**Figure C-5b:** *Non-semester Pre-/Post-Retrofit Comparison:* **based on average hourly data (Sims Elementary School)**



The weekend consumption decreased over all hours between the pre-retrofit and post-retrofit periods. This is indicative of equipment being left on over the weekend during the pre-retrofit period, which is now being turned off by the EMCS.

For the non-semester period, Figure C-5b, similar results as the semester period occur. The weekday consumption dramatically decreased during the nighttime hours, but dramatically increased during the daytime hours. This may be due to the same reasons stated above in the semester period analysis. For the weekends, there was an overall decrease in consumption over all hours. The consumption increases between the hours of 12:00 p.m. and 10:00 p.m. This may be due to faculty and staff working later in the day on weekends.

Tab C-3 contains a summary of the hourly averages and the respective standard deviations and count of data points. The hourly averages are the data that is plotted in Figures C-5a and C-5b. They do not vary much for the hours of 0 through 7, then jump to higher levels in the hours of 8 through 23. This should not be alarming, because the periods that the data was averaged over include wide ranges of temperatures. As was seen earlier in Figures C-1 and C-2, the energy usage is temperature dependent. The count of data points represents the actual number of data points used to calculated the average, which corresponds to the amount of time that the equipment was actually operating.

The difference in other electric energy consumption was calculated based on the average daily data. This is shown in Table C-3, both as a difference in energy and a percentage difference in energy.

**Table C-3:** ***Difference in Other Electric Consumption*** **based on average daily data (Sims Elementary School)**

| | # days in period | Average Daily Consumption kWh/day | Difference in Average Daily Consumption kWh/period | % Difference in Average Daily Consumption |
|---|---|---|---|---|
| Semester | | | | |
| weekday-pre | 514 | 1,453 | | |
| weekday-post | 229 | 1,617 | 164 | 11.29% |
| weekend-pre | 192 | 861 | | |
| weekend-post | 88 | 444 | -417 | -48.41% |
| Non-Semester | | | | |
| weekday-pre | 148 | 1-517 | | |
| weekday-post | 66 | 1,479 | -38 | -2.48% |
| weekend-pre | 72 | 1,235 | | |
| weekend-post | 543 | -692 | -692 | -56.03% |

## C.3.6 Plots from MECR

The September MECR energy use plots for four years are shown in Tab C-4. These provide a more qualitative look at the effects of the EMCS. September 1992 is a pre-retrofit plot. Note that there is relatively high consumption between the hours of midnight to 6:00 a.m., with a gradual increase to daytime levels. This is followed by a slow decrease in consumption between the hours of 4:00 p.m. and 10:00 p.m. Most afternoon and evening consumption does not drop to nighttime levels. September 1993 is also a pre-retrofit plot, but shows slight improvement in afternoon, evening, and nighttime consumption. There is a measurable decrease in consumption in the afternoon. Although consumption between the hours of 7:00 p.m. and midnight is not as low as the hours of midnight to 6:00 a.m., there are greatly reduced when compared to September 1991. September 1994 is a post-retrofit plot. This plot displays all the telltale signs of an EMCS. The nighttime consumption is very low, with a sharp increase to daytime levels at 6:00 a.m. The consumption drops dramatically from daytime levels to nighttime levels at 4:00 p.m. There are two or three afternoons where the consumption id slightly higher than nighttime levels. This could be due to occasional special events in which certain areas of the school remain in use after hours.

It should be noted that these profiles only allow a good look at weekday data only. The weekend data is virtually unreadable from these plots. The September 1994 plots shows a typical "picket fence" pattern on the Day-of-Year axis of the top plot. This shows the weekday consumption as the peaks, and the weekend consumption as the troughs. Separating the data into weekdays and weekends, then plotting separately would enable one to better evaluate weekends, as well as weekdays.

### C.3.7 Data Summary Notebook Information

The Data Summary Notebook information is included in Tab C-5. It is not analyzed in this report for this site. Since it is analyzed for Zachry Engineering Center, it is provided for informational purposes only.

# Tab C-1

## School District Schedules

people x hr/day. $/mo
people x day/month

# FORT WORTH INDEPENDENT SCHOOL DISTRICT
# 1990-91 SCHOOL CALENDAR

## AUGUST — 1990

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 PAYROLL CLOSES | 6 | 7 PAYROLL DUE | 8 | 9 | 10 ALL ADM'S MEETING | 11 |
| 12 | 13 | 14 | 15 | 16 NEW TEACHERS INSERVICE | 17 | 18 |
| 19 | 20 ☆ CONVOCATION | 21 ○ | 22 ○ | 23 ○ | 24 ★ | 25 |
| 26 | 27 ( SCHOOL STARTS | 28 | 29 | 30 | 31 PAYDAY | |

## SEPTEMBER — 1990

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 PAYROLL CLOSES | 3 • LABOR DAY | 4 PAYROLL DUE | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 ROSH HASHANAH | 21 | 22 |
| 23/30 PAYROLL CLOSES | 24 | 25 | 26 | 27 | 28 PAYDAY YOM KIPPUR | 29 |

## OCTOBER — 1990

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 | 2 PAYROLL DUE | 3 | 4 SUKKOT | 5 ) 1ST 6 WKS 29 DAYS | 6 STATE FAIR |
| 7 | 8 ( | 9 | 10 | 11 SUKKOT | 12 | 13 |
| 14 | 15 REPORT CARDS | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 PAYDAY | | | |

## NOVEMBER — 1990

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 PAYROLL CLOSES | 5 | 6 PAYROLL DUE | 7 | 8 | 9 | 10 |
| 11 | 12 AMERICAN EDUCATION WEEK | 13 | 14 | 15 | 16 ) 2ND 6 WKS 30 DAYS | 17 |
| 18 | 19 ( | 20 | 21 PAYDAY | 22 • THANKSGIVING | 23 • | 24 |
| 25 PAYROLL CLOSES | 26 | 27 PAYROLL DUE | 28 REPORT CARDS | 29 | 30 | |

## DECEMBER — 1990

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 CHANUKAH | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 CHANUKAH | 19 PAYDAY | 20 • WINTER BREAK | 21 • | 22 |
| 23/30 PAYROLL CLOSES | 24 •/• 31 | 25 • WINTER BREAK | 26 • | 27 • | 28 • | 29 |

## JANUARY — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | 1 • NEW YEAR'S DAY | 2 PAYROLL DUE | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 ) 3RD 6 WKS 29 DAYS | 12 |
| 13 | 14 ○ | 15 ○ | 16 ( | 17 | 18 | 19 |
| 20 | 21 • M.L.K. | 22 REPORT CARDS | 23 | 24 | 25 PAYDAY | 26 |
| 27 | 28 | 29 | 30 | 31 | | |

## FEBRUARY — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 •‖ STOCK SHOW | 2 |
| 3 PAYROLL CLOSES | 4 | 5 PAYROLL DUE | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 PAYDAY | | |

## MARCH — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 ) 4TH 6 WKS 31 DAYS | 2 |
| 3 PAYROLL CLOSES | 4 ( PUBLIC SCHOOL WEEK | 5 PAYROLL DUE | 6 | 7 | 8 | 9 |
| 10 | 11 REPORT CARDS | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 • SPRING BREAK | 19 • | 20 • | 21 • | 22 • | 23 |
| 24/31 PAYROLL CLOSES EASTER PASSOVER | 25 | 26 | 27 | 28 PAYDAY | 29 ✻‖ GOOD FRI SNOW DAY | 30 PASSOVER |

## APRIL — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 | 2 PAYROLL DUE | 3 | 4 | 5 PASSOVER | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 ) 5TH 6 WKS 29 DAYS | 20 |
| 21 | 22 ( | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 REPORT CARDS | 30 PAYDAY | | | | |

## MAY — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 PAYROLL CLOSES | 6 | 7 PAYROLL DUE | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 SHAVUOT |
| 19 SHAVUOT | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 ▲✻ MEMORIAL DAY | 28 | 29 ) 6TH 6 WKS 27 DAYS | 30 ★ PAYDAY | 31 | |

## JUNE — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 PAYROLL CLOSES | 3 | 4 PAYROLL DUE | 5 | 6 REPORT CARDS | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23/30 PAYROLL CLOSES | 24 | 25 | 26 | 27 | 28 PAYDAY | 29 |

## JULY — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 | 2 PAYROLL DUE | 3 | 4 • FOURTH OF JULY | 5 | 6 |
| 7 | 8 VACATION | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 VACATION | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 PAYDAY | | | |

## AUGUST — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 PAYROLL CLOSES | 5 | 6 PAYROLL DUE | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 PAYDAY | 31 |

○ INSERVICE/TEACHERS' PREPARATION
• HOLIDAY
☆ INSERVICE
★ TEACHERS' PREPARATION DAYS
✻ SNOW DAYS
( BEGINNING OF SIX WEEKS
) END OF SIX WEEKS
▲ MOC WORKS

### 1990-91 STANDARDIZED TEST DATES

SAT:
October 13, 1990
(Texas is one of nine states giving test on this date)
November 3, 1990
December 1, 1990
January 26, 1991
March 16, 1991
May 4, 1991
June 1, 1991

PSAT:
October 20, 1990 - Sat.
October 23, 1990 - Tues.

ACT
October 27, 1990
December 8, 1990
February 9, 1991
April 13, 1991
June 8, 1991

ITBS/TAP Grades 2, 4, 5, 6, 8, 10
April 8-19, 1991

Local Advanced Placement Examination.
August 10, 1990 — June 7, 1991
January 12, 1991 — August 9, 1991

TAAS Grades 3, 5, 7, 9, and Exit Level:

| | | |
|---|---|---|
| Tuesday | October 16, 1990 | Writing |
| Wednesday | October 17, 1990 | Reading |
| Thursday | October 18, 1990 | Mathematics |

TAAS Exit Level:

| | | |
|---|---|---|
| Tuesday | April 2, 1991 | Writing |
| Wednesday | April 3, 1991 | Reading |
| Thursday | April 4, 1991 | Mathematics |

### Teaching Days

1st Semester

| | | |
|---|---|---|
| 1st | 6 weeks | 29 days |
| 2nd | 6 weeks | 30 days |
| 3rd | 6 weeks | 29 days |
| Fall Semester | | 88 days |

2nd Semester

| | | |
|---|---|---|
| 4th | 6 weeks | 31 days |
| 5th | 6 weeks | 29 days |
| 6th | 6 weeks | 27 days |
| Spring Semester | | 87 days |

Teacher Preparation/Inservice
Aug 20, 21, 22, 23, 24
Jan. 14, 15
May 30

Imagination Celebration
April 7-13

‖ Feb. 1 - All 12 month contract personnel will work.
✻ Snow Day or Holiday
‖ March 29 - All 12 month contract personnel will work. Holiday if not a Snow Day for students, teachers, ten month and eleven month contract personnel. May 27 - A snow make-up day or holiday for all personnel EXCEPT 260 DAY CONTRACT.

FORT WORTH
INDEPENDENT SCHOOL DISTRICT
*Quality Education For All*

# FORT WORTH INDEPENDENT SCHOOL DISTRICT
# 1991-92 SCHOOL CALENDAR

## AUGUST — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 PAYROLL CLOSES | 5 | 6 PAYROLL DUE | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 * | 16 ALL NEW MEETING | 17 |
| 18 | 19 NEW TEACHERS WORKSHOP ORIENTATION | 20 | 21 | 22 | 23 ★ | 24 |
| 25 | 26 ( SCHOOL STARTS | 27 | 28 | 29 | 30 * PAYDAY | 31 |

## SEPTEMBER — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| 1 PAYROLL CLOSES | 2 • LABOR DAY | 3 PAYROLL DUE | 4 | 5 | 6 | 7 |
| 8 | 9 ROSH HASHANAH | 10 | 11 | 12 | 13 * | 14 |
| 15 | 16 | 17 YOM KIPPUR | 18 | 19 | 20 | 21 |
| 22 | 23 SUKKOT | 24 | 25 | 26 | 27 | 28 |
| 29 PAYROLL CLOSES | 30 * PAYDAY SUKKOT | | | | | |

## OCTOBER — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | 1 SUKKOT PAYROLL DUE | 2 | 3 | 4 ) 1ST 6 WKS 29 DAYS | 5 |
| 6 | 7 ( | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 REPORT CARDS | 15 * | 16 | 17 | 18 | 19 STATE FAIR |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 | 31 * PAYDAY | | |

## NOVEMBER — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 PAYROLL CLOSES | 4 | 5 PAYROLL DUE | 6 | 7 | 8 | 9 |
| 10 | 11 AMERICAN EDUCATION WEEK | 12 | 13 | 14 | 15 * ) 2ND 6 WKS 30 DAYS | 16 |
| 17 | 18 ( | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 REPORT CARDS | 26 | 27 * PAYDAY | 28 THANKSGIVING | 29 | 30 |

## DECEMBER — 1991

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| 1 PAYROLL CLOSES | 2 | 3 PAYROLL DUE CHANUKAH | 4 | 5 | 6 | 7 |
| 8 PAYROLL CLOSES | 9 CHANUKAH | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 * PAYDAY | 21 |
| 22 | 23 • WINTER BREAK | 24 • | 25 • | 26 • | 27 • | 28 |
| 29 | 30 • WINTER BREAK | 31 • | | | | |

## JANUARY — 1992

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | 1 • NEW YEAR'S DAY | 2 ▲ • WINTER BREAK | 3 ▲ • | 4 |
| 5 PAYROLL CLOSES | 6 PAYROLL DUE | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 * | 16 ) 3RD 6 WKS 32 DAYS | 17 ★ | 18 |
| 19 | 20 • MLK | 21 ( | 22 | 23 | 24 PAYDAY | 25 |
| 26 | 27 REPORT CARDS | 28 | 29 | 30 * | 31 ♦ • — STOCK SHOW | |

## FEBRUARY — 1992

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 PAYROLL CLOSES | 3 | 4 PAYROLL DUE | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 * | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 * ) 4TH 6 WKS 28 DAYS PAYDAY | 29 |

## MARCH — 1992

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| 1 PAYROLL CLOSES | 2 ( PUBLIC SCHOOL WEEK | 3 PAYROLL DUE | 4 | 5 | 6 | 7 |
| 8 | 9 REPORT CARDS | 10 | 11 | 12 | 13 * | 14 |
| 15 | 16 • SPRING BREAK | 17 • | 18 • | 19 • | 20 • | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 * PAYDAY | | | | |

## APRIL — 1992

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 PAYROLL CLOSES | 6 | 7 PAYROLL DUE | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 * | 16 ) 5TH 6 WKS 29 DAYS | 17 ✧ GOOD FRI SNOW DAY | 18 PASSOVER |
| 19 PASSOVER EASTER | 20 ( | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 REPORT CARDS | 28 | 29 | 30 * PAYDAY | | |

## MAY — 1992

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 PAYROLL CLOSES | 4 | 5 PAYROLL DUE | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 * | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 / 31 | 25 MEMORIAL DAY | 26 | 27 | 28 | 29 * PAYDAY | 30 |

## JUNE — 1992

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 | 2 ○ ) LAST DAY 6TH 6 WKS 32 DAYS | 3 ✧ SNOW DAY | 4 ☆ ★ | 5 | 6 SHAVUOT |
| 7 PAYROLL CLOSES SHAVUOT | 8 PAYROLL DUE | 9 | 10 REPORT CARDS | 11 | 12 | 13 |
| 14 | 15 * | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 * PAYDAY | | | | |

## JULY — 1992

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 • HOLIDAY | 4 |
| 5 PAYROLL CLOSES | 6 VACATION | 7 PAYROLL DUE | 8 | 9 | 10 | 11 |
| 12 | 13 VACATION | 14 | 15 * | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | 31 * PAYDAY | |

## AUGUST — 1992

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 PAYROLL CLOSES | 3 | 4 PAYROLL DUE | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 * | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 / 30 | 24 * / 31 | 25 | 26 | 27 | 28 | 29 |

### 1991-92 STANDARDIZED TESTING DATES

SAT:
October 12, 1991 - Texas only
November 2, 1991
December 7, 1991
January 25, 1992
April 4, 1992
May 2, 1992
June 6, 1992

PSAT/NMSQT:
October 19, 1991 - Saturday
October 22, 1991 - Tuesday

ACT:
October 26, 1991
December 14, 1991
February 8, 1992
April 11, 1992
June 13, 1992

TAAS Norm-Referenced Testing
Grades 3, 4, 5, 6, 7, 8, 9, 10, and 11
Tuesday, April 7, 1992
Wednesday, April 8, 1992
Thursday, April 9, 1992

TAAS Criterion-Referenced Testing
Grades 3, 5, 7, 9, and Exit Level

| | |
|---|---|
| Tues., October 8, 1991 | Writing |
| Wed., October 9, 1991 | Reading, TEAMS Exit Level ELA |
| Thur., October 10, 1991 | Mathematics, TEAMS Exit Level M |

Exit Level

| | |
|---|---|
| Tues., March 31, 1992 | Writing |
| Wed., April 1, 1992 | Reading, TEAMS Exit Level ELA |
| Thurs., April 2, 1992 | Mathematics, TEAMS Exit Level M |

Local Advanced Placement Examination
August 9, 1991
January 11, 1992
May 30, 1992
August 8, 1992

C-16

SCIENCE FAIR - March 31 - April 5, 1992
PTA COUNCIL - 1st Wednesday of every month

• HOLIDAY
( BEGINNING OF SIX WEEKS
) END OF SIX WEEKS
▲ MOC WORKS
★ TEACHERS' PREPARATION DAYS

**Teaching Days**

1st Semester

| | | |
|---|---|---|
| 1st | 6 weeks | 29 days |
| 2nd | 6 weeks | 30 days |
| 3rd | 6 weeks | 32 days |
| Fall Semester | | 91 days |

2nd Semester

| | | |
|---|---|---|
| 4th | 6 weeks | 28 days |
| 5th | 6 weeks | 29 days |
| 6th | 6 weeks | 32 days |
| Spring Semester | | 89 days |

Teacher Preparation
August 23
January 17
June 4

First Student Day
August 26, 1991

History Fair
March 9-13, 1992

Social Studies Symposium
March 27-28, 1992

College Board Advanced Placement Exams
May 6-19, 1992

All-City Baccalaureate
May 24, 1992

Literacy Conference
June 22-24, 1992

— January 31 - Workday for all employees on 240 day contracts
✧ Snow Days April 17 and June 3
* Semi-Monthly Payroll
♦ Stock Show Holiday

○ LAST DAY (if second snow day is not needed)
✧ SNOW DAY if not needed will be TEACHER PREP DAY:

FORT WORTH
INDEPENDENT SCHOOL DISTRICT

*Where the Future Begins...NOW!*

# Fort Worth Independent School District
# 1992-93 SCHOOL CALENDAR

### AUGUST 1992

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 Payroll Closes | 3 | 4 Payroll Due | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 ] | 15 |
| 16 | 17 NEW | 18 TEACHER | 19 INSERVICE | 20 | 21 ✲ | 22 |
| 23/30 | 24 School Starts / 31 Payday | 25 | 26 | 27 | 28 | 29 |

### SEPTEMBER

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 6 Payroll Closes | (7) Labor Day | 8 Payroll Due | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 ] | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 ROSH | 28 HASHANAH | 29 | 30 Payday | | | |

### OCTOBER

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 Payroll Closes | 5 | 6] 31 Days Payroll Due | {7 YOM KIPPUR | 8 | 9 | 10 |
| 11 SUKKOT | 12 | 13 | 14 Report Cards | 15 ] | 16 | 17 |
| 18 SUKKOT | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 Payday | 31 |

### NOVEMBER

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| 1 Payroll Closes | 2 | 3 Payroll Due | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 ] | 14 |
| 15 | 16 | 17] 30 Days | {18 AMERICAN | 19 EDUCATION | 20 WEEK | 21 |
| 22 | 23 | 24 | 25 PAYDAY Report Cards | 26 THANKS | 27 GIVING | 28 |
| 29 Payroll Closes | 30 | | | | | |

### DECEMBER

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | 1 Payroll Due | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 Payday ] | 19 Chanukah |
| 20 | 21 ✱ | 22 ✱ WINTER | 23 BREAK | 24 | 25 Christmas | 26 |
| 27 Chanukah | 28 | 29 WINTER | 30 BREAK | 31 | | |

### JANUARY 1993

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 New Year's | 2 |
| 3 Payroll Closes | 4 | 5 Payroll Due | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14] 30 Days | 15 ✲ | 16 |
| 17 | (18) M. L. King | {19 | 20 | 21 | 22 | 23 |
| 24/31 Payroll Closes | 25 Report Cards | 26 | 27 Payday | 28 | 29 | 30 |

### FEBRUARY

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 | 2 Payroll Due | 3 | 4 | (5) Stock Show | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 ] | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 Payday | 27 |
| 28 Payroll Closes | | | | | | |

### MARCH

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 PUBLIC | 2 Payroll Due SCHOOL | 3 | 4] WEEK | {5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 ] Report Cards | 13 |
| 14 | 15 | 16 SPRING | 17 BREAK | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 Payday | | | |

### APRIL

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 Payroll Closes | 5 Passover | 6 Payroll Due | 7 Passover | 8 | 9 Good Friday | 10 |
| 11 Easter PESACH | 12 | 13 | 14 | 15 ] | 16] | 17 |
| 18 | 19 | {20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 Report Cards | 28 | 29 | 30 Payday | |

### MAY

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 Payroll Closes | 3 | 4 Payroll Due | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 ] | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23/30 | 24/31 | 25 SHAVOUT | 26 | 27 | 28 | 29 |

### JUNE

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | 1 | 2] | 3 ✲ | 4 | 5 |
| 6 Payroll Closes | 7 | 8 Payroll Due | 9 | 10 Report Cards | 11 | 12 |
| 13 | 14 | 15 ] | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 Payday | | | |

### JULY

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 Payroll Closes | (5) Holiday | 6 Payroll Due | 7 | 8 | 9 | 10 |
| 11 | 12 VACATION | 13 | 14 | 15 ] | 16 | 17 |
| 18 | 19 VACATION | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 Payday | 31 |

### AUGUST 1993

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| 1 Payroll Closes | 2 | 3 Payroll Due | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 ] | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 Payday | | | | |

⬭ Holiday ☀ Snow Days ✲ Teachers' Preparation Days ✱ MOC Works [ Beginning of Six Weeks ] End of Six Weeks
] Semi-Monthly Payroll ⇨ February 5 - Workday for All Employees on 240 Day Contracts

FORT WORTH
INDEPENDENT SCHOOL DISTRICT
*Where the Future Begins... Now*

## Meetings & Events

**Regular Board Meeting**
*2nd & 4th Tuesday of each month*
**Imagination Celebration Festival Week**
April 1-7, 1993
**PTA Council** *1st Wednesday of each month*
**Literacy Conference** *June 22-24, 1993*
**Drug Free Schools & Community Survey**
**Because We Care** *March 3, 1993*
**College Night** *September 23*

## Teaching Days

**First Semester**
- *1st Six Weeks* — *31 Days*
- *2nd Six Weeks* — *30 Days*
- *3rd Six Weeks* — *30 Days*
- *Fall Semester* — *91 Days*

**Second Semester**
- *1st Six Weeks* — *32 Days*
- *2nd Six Weeks* — *25 Days*
- *3rd Six Weeks* — *32 Days*
- *Spring Semester* — *89 Days*

**Teacher Preparation** *August 21, 1992*, *January 15, 1993*, *June 3, 1993*
**First Student Day** *August 24, 1992*
**Snow Days** *April 9, 1993* *April 19, 1993*
**Last Day** *June 2, 1993*

## Standardized Testing Dates

**Scholastic Aptitude Test (SAT)**
October 10, 1992
November 7, 1992
December 5, 1992
January 23, 1993
March 27, 1993
May 1, 1993
June 5, 1993

**Preliminary Scholastic Aptitude Test (PSAT/NMSQT)**
October 17, 1992-Saturday
October 22, 1992-Thursday

**American College Testing Program (ACT)**
October 24, 1992 *(Registration Deadline September 25, 1992)*
December 12, 1992 *(Registration Deadline November 13, 1992)*
February 6, 1993 *(Registration Deadline January 8, 1993)*
April 3, 1993 *(Registration Deadline March 5, 1993)*
June 12, 1993 *(Registration Deadline May 14, 1993)*

**Texas Assessment of Academic Skills (TAAS)/Texas Educational Assessment of Minimum Skills (TEAMS)**
September 22-24, 1992 Grades 3 and 7 (TAAS ONLY)
October 27-29, 1992 Grades 11 and 12
May 4-6, 1993 Grades 4, 8, 10, 11, 12

**Norm-Referenced Assessment Program of Texas (NAPT)**
April 12-16, 1993 Grades 3, 4, 5, 6, 7, 8, 9, 10, and 11

**Local Advanced Placement Examination**
August 8, 1992 January 16, 1993 June 12, 1993 August 7, 1993

**College Board Advanced Placement Examinations**
May 5-18, 1993

# Fort Worth Independent School District
# 1993-94 SCHOOL CALENDAR

### AUGUST 1993

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| 1 Payroll Closes | 2 | 3 Payroll Due | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | ★13 Semi-Monthly Payday | 14 |
| 15 | 16 School Starts | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 Payday | | | | |

### SEPTEMBER 1993

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 Payroll Closes | 6 Labor Day | 7 Payroll Due | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 Semi-Monthly Payday | 16 Rosh Hashanah | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 Yom Kippur |
| 26 | 27 | 28 | 29 | 30 Payday | | |

### OCTOBER 1993

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 Payroll Closes | 4 | 5 Payroll Due | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 Semi-Monthly Payday | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 / Payroll Closes 31 | 25 | 26 | 27 | 28 | 29 Payday | 30 |

### NOVEMBER 1993

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 | 2 Payroll Due | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 Semi-Monthly Payday | 16 | 17 | 18 | 19 | 20 |
| | AMERICAN EDUCATION WEEK | | | | | |
| 21 | 22 | 23 | 24 Payday | 25 | 26 | 27 |
| | | | | THANKSGIVING | | |
| 28 Payroll Closes | 29 | 30 Semi-Monthly Payday & Payroll Due | | | | |

### DECEMBER

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 Chanukah | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 Chanukah | 17 Payday | 18 |
| 19 | 20 MOC Works | 21 MOC Works | 22 | 23 | 24 | 25 Christmas |
| | WINTER BREAK | | | | | |
| 26 | 27 | 28 | 29 | 30 | 31 | |
| | WINTER BREAK | | | | | |

### JANUARY 1994

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | | 1 New Years |
| 2 Payroll Closes | ★3 | 4 Payroll Due | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 Semi-Monthly Payday | 15 |
| 16 | 17 ML King | 18 | 19 | 20 | 21 | 22 |
| 23 / Payroll Closes 30 | 24 / Semi-Monthly Payday 31 | 25 | 26 | 27 Payday | 28 | 29 |

### FEBRUARY 1994

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | 1 Payroll Due | 2 | 3 | 4 Stock Show | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 Semi-Monthly Payday | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 PURIM | 26 |
| 27 Payroll Closes | 28 Payday | | | | | |

### MARCH 1994

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | 1 Payroll Due | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 Semi-Monthly Payday | 12 |
| | PUBLIC SCHOOL WEEK | | | | | |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | SPRING BREAK | | | | | |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 Pesach |
| 27 | 28 | 29 | 30 | 31 Payday | | |

### APRIL 1994

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | ● 1 Good Friday | 2 |
| | | | | | PESACH | |
| 3 Payroll Closes | ●4 | 5 Payroll Due | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 Semi-Monthly Payday | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 Payday | 30 |

### MAY 1994

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| 1 Payroll Closes | 2 | 3 Payroll Due | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 Semi-Monthly Payday | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | SHAVOT | | | | | |
| 22 | 23 | 24 | 25 School Year Ends | ★26 Teacher Preparation | 27 | 28 |
| 29 | 30 Memorial Day | 31 Payday | | | | |

### JUNE 1994

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 Payroll Closes | 6 | 7 Payroll Due | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 Semi-Monthly Payday | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 Payday | | |

### JULY 1994

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 Payroll Closes | 4 Independence Day | 5 Payroll Due | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 Semi-Monthly Payday | 16 |
| | VACATION | | | | | |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| | VACATION | | | | | |
| 24 / Payroll Closes 31 | 25 | 26 | 27 | 28 | 29 Payday | 30 |

### AUGUST 1994

| SUN | MON | TUE | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 | 2 Payroll Due | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 Semi-Monthly Payday | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 Payday | | | |

◯ Holiday ● Snow Days ★ Teachers' Preparation Days ✱ MOC Works
February 4, April 4 - Workdays for All Employees on 240 Day Contracts

## Traditional Calendar

Administrators Meeting *Tuesday, August 10, 1993*
First Day of School *Monday, August 16, 1993*
Last Day of School *Wednesday, May 25, 1994*
Teacher Preparation Days *Aug. 13, January 3, May 26*
First Semester (Total 87 Days)
1st Six Weeks 29 Days (ends 9/24)
2nd Six Weeks 30 Days (ends 11/5)
3rd Six Weeks 28 Days (ends 12/17)
Second Semester (Total 93 Days)
4th Six Weeks 32 Days (ends 2/18)
5th Six Weeks 28 Days (ends 4/8)
6th Six Weeks 33 Days (ends 5/25)
Report Card Dates
10/5/93 3/1/94
11/16/93 4/19/94
1/11/94 6/3/94 (Mailed)

## Year-Round Calendar

Alice Carlson ES J.P. Elder MS
Hubbard ES Kirkpatrick MS
N. Hi Mount ES Stripling MS
Versia Williams ES Meadowbrook MS (dual)

First Day of School Monday, July 26, 1993
Last Day of School Tuesday, June 14, 1994
Teacher Preparation Days July 23, Jan. 7, June 15

1st Nine Weeks July 26/Sept. 24 44 days
2nd Nine Weeks Oct. 18/Dec. 17 43 Days
3rd Nine Weeks Jan. 10/Mar. 11 43 Days
4th Nine Weeks Apr. 4/June 14 50 Days

Report Card Dates
10/5/93 3/29/94
1/11/94 6/24/94 (Mailed)
Intersessions
9/25/93 - 10/15/93 3/21/94 - 4/1/94
1/3/94 - 1/7/94 6/15/94 - 7/1/94

## Meetings & Events

Regular Board Meeting
*2nd & 4th Tuesday of each month*
Imagination Celebration Festival Week
*April 5-10 (Tentative)*
FWISD Fair *Ridgmar Mall, November 13, 1993*
PTA Council *1st Wednesday of each month*
Literacy Conference *June 13-15, 1994*
History Fair *March 7-12, 1994*
Because We Care *March 2, 1994*
College Night *September 20, 1993*
Social Studies Symposium *April 22-23, 1994*

## Other Calendar Dates

Snow Days *April 1, 1994 April 4, 1994*
Early Release Days *November 24, 1993*
*December 17, 1993 March 11, 1994*
MOC Non-Contract Day *November 26, 1993*

## Year-Round Calendar (Special)

W.J. Turner ES First Day of School August 23, 1993 Last Day of School June 29, 1994
Intersessions 10/25/93 - 10/29/93 3/21/94 - 3/25/94 5/9/94 - 5/20/94
Teacher Preparation Days August 20, January 14, June 30

B.H. Carroll/New Lives First Day of School Aug. 31, 1993 Last Day of School Aug. 5, 1994
Intersessions 10/13/93 - 10/22/93 2/16/94 - 2/25/94
4/20/94 - 4/29/94 5/13/94 - 6/24/94
Teacher Preparation Days August 30

Middle Learning Learning Center & Horizons Alternative School
First Day of School - Aug 23, 1993 Last Day of School - August 1, 1994
Intersessions 8/16/93 - 8/20/93 10/4/93 - 10/8/93 11/29/93 - 12/3/93
2/7/94 - 2/18/94 4/11/94 - 4/22/94 6/6/94 - 6/17/94
Teacher Preparation Days 8/13/93 8/20/93 8/2/94

See reverse side for list of 1993-94 Standardized Testing Dates and Professional Development Waiver Days

FORT WORTH
INDEPENDENT SCHOOL DISTRICT
*Where the Future Begins... Now*
Student Services Department

# Tab C-2

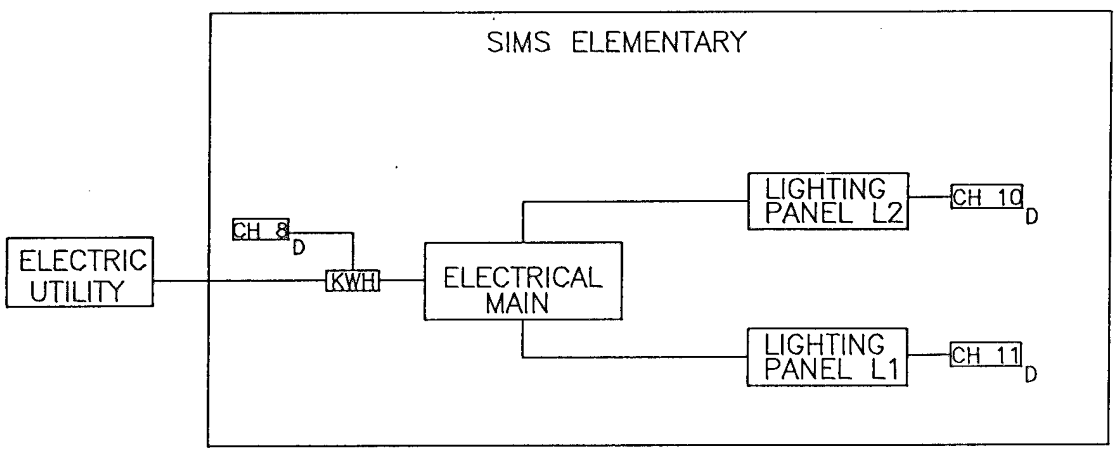
## Monitoring Diagrams

# ELECTRICAL MONITORING DIAGRAM

## FWISD – SIMS ELEMENTARY

LEGEND

K=KWH CHANNEL
A=ANALOG CHANNEL
D=DIGITAL CHANNEL



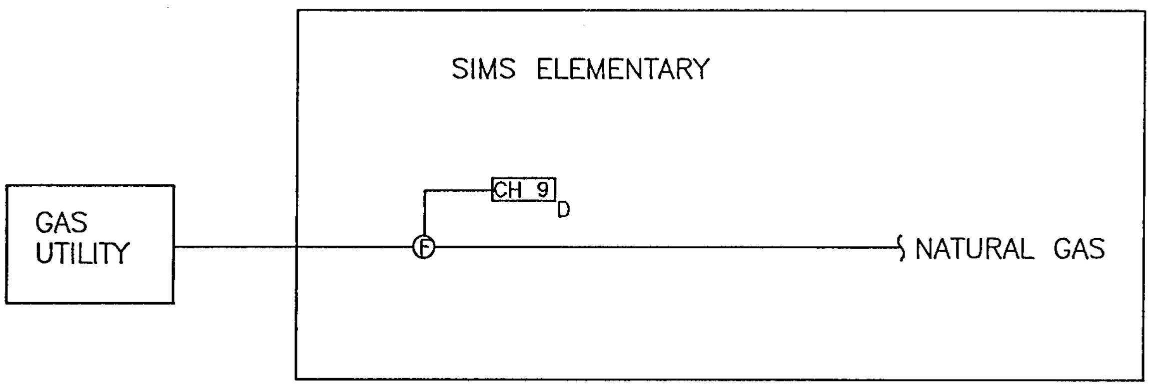

FWISD/SIMS ELEMENTARY – SITE 128

# THERMAL MONITORING DIAGRAM

## FWISD – SIMS ELEMENTARY

LEGEND

K=KWH CHANNEL
A=ANALOG CHANNEL
D=DIGITAL CHANNEL
PC=PUMPED CONDENSATE




FWISD/SIMS ELEMENTARY – SITE 128

## Tab C-3

## Average Hourly Data & Related Statistics

**Hourly Average**

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 37.0036 | 34.6782 | 33.5772 | 32.5043 | 31.8931 | 31.7685 | 35.5423 | 67.5258 | 83.4425 | 100.5710 | 96.9066 | 100.8703 | 100.6826 | 99.1445 | 78.8711 | 76.1071 | 70.4806 | 58.2544 | 56.0906 | 50.0857 | 46.9472 | 44.9806 | 43.6201 | 41.0804 |
| 1-B-S | 20.0102 | 18.7364 | 18.8158 | 18.7534 | 18.8949 | 18.8548 | 20.7021 | 78.8397 | 130.7057 | 144.7100 | 140.1736 | 145.2108 | 148.9078 | 150.6077 | 134.4668 | 124.7947 | 112.3719 | 31.0357 | 28.5612 | 22.8565 | 22.6486 | 22.4486 | 22.0493 | 21.4389 |
| 0-A-S | 36.6417 | 34.8380 | 33.6766 | 32.6698 | 32.1526 | 31.7146 | 32.9667 | 33.6214 | 32.7068 | 31.7734 | 32.5677 | 33.8953 | 35.7568 | 37.3995 | 39.0443 | 40.5375 | 41.3922 | 42.2656 | 42.3281 | 38.7661 | 37.7224 | 36.2891 | 35.4797 | 34.4073 |
| 0-B-S | 18.4023 | 17.6341 | 17.8034 | 17.6602 | 17.8761 | 17.7330 | 17.8148 | 18.0716 | 19.6420 | 20.4750 | 20.1636 | 21.6159 | 21.8750 | 21.5739 | 21.5398 | 19.2636 | 18.4591 | 16.9886 | 15.7375 | 15.9205 | 16.9420 | 16.9659 | 16.9830 | 16.8375 |
| 1-A-NS | 55.5791 | 54.1007 | 52.5345 | 51.4635 | 51.2608 | 51.3932 | 53.3405 | 54.6622 | 55.6014 | 59.8851 | 64.3804 | 67.6932 | 72.0736 | 72.2703 | 75.4169 | 78.4500 | 79.0831 | 74.8385 | 74.5493 | 69.6696 | 66.8527 | 63.2270 | 60.6041 | 57.9047 |
| 1-B-NS | 17.2152 | 16.4318 | 16.4712 | 16.9106 | 16.7061 | 16.9197 | 20.6152 | 71.4348 | 142.4515 | 117.3939 | 117.0091 | 118.6758 | 123.6848 | 126.9273 | 131.2909 | 134.1773 | 135.8288 | 26.8879 | 20.1788 | 19.2803 | 19.3894 | 17.7742 | 17.7152 | 17.8803 |
| 0-A-NS | 47.4986 | 46.3347 | 45.2111 | 44.3153 | 43.4833 | 42.8083 | 43.5750 | 44.9514 | 43.5278 | 44.4764 | 45.6597 | 48.5861 | 52.4250 | 56.0236 | 59.5708 | 61.9347 | 63.8139 | 64.8264 | 65.3097 | 60.4861 | 57.8750 | 53.6306 | 51.0958 | 47.9958 |
| 0-B-NS | 15.3167 | 14.4500 | 14.5500 | 14.8667 | 14.6167 | 14.5833 | 14.5333 | 14.4667 | 13.0000 | 12.9167 | 12.9833 | 13.7333 | 21.0000 | 33.3333 | 44.4167 | 43.9167 | 43.9667 | 43.7167 | 40.3333 | 34.6167 | 24.1167 | 14.9167 | 14.6000 | 14.3167 |

**Standard Deviation of the Hourly Average**

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 19.9990 | 18.2734 | 17.1404 | 15.9362 | 15.2392 | 14.7920 | 22.1803 | 26.8747 | 28.6124 | 35.7241 | 38.7061 | 39.2554 | 41.8580 | 43.3770 | 46.8005 | 48.2200 | 47.2362 | 41.2426 | 39.6589 | 30.5220 | 28.0553 | 25.4724 | 24.1189 | 22.3496 |
| 1-B-S | 3.8050 | 3.6130 | 3.7557 | 3.7925 | 3.8605 | 4.3225 | 6.8660 | 41.2560 | 47.3032 | 49.8258 | 49.3742 | 51.4970 | 51.9090 | 55.4547 | 54.3160 | 54.0045 | 49.4474 | 8.2090 | 6.6093 | 6.7973 | 4.7903 | 5.0042 | 4.6938 | 3.9888 |
| 0-A-S | 19.5435 | 17.8464 | 16.9142 | 15.5978 | 14.7928 | 14.3711 | 18.7134 | 21.4453 | 19.6484 | 19.6792 | 20.8988 | 22.1807 | 24.2556 | 26.5095 | 28.1421 | 30.0331 | 31.2929 | 31.9350 | 32.1834 | 24.0701 | 23.2322 | 21.0007 | 19.8207 | 18.8588 |
| 0-B-S | 4.3559 | 4.1117 | 4.0953 | 4.1590 | 4.3359 | 4.2513 | 4.2423 | 5.7722 | 11.5400 | 14.2388 | 14.1773 | 19.4363 | 20.3196 | 20.1319 | 21.0800 | 14.1179 | 13.7331 | 8.0694 | 3.5504 | 3.6415 | 3.7757 | 3.7913 | 3.9263 | 4.6412 |
| 1-A-NS | 32.0022 | 30.4493 | 29.0301 | 27.9213 | 27.0277 | 26.5548 | 28.0308 | 29.9100 | 31.7639 | 35.5873 | 38.6963 | 41.9961 | 44.8028 | 44.8824 | 47.0708 | 49.3619 | 50.4176 | 48.9894 | 48.7986 | 44.1216 | 42.0862 | 39.1198 | 36.5888 | 34.1911 |
| 1-B-NS | 3.3931 | 3.5976 | 3.7856 | 3.7244 | 3.9595 | 3.8705 | 6.1481 | 36.8472 | 68.5668 | 53.1475 | 53.5467 | 55.5704 | 57.5960 | 59.7648 | 63.3602 | 65.4916 | 65.7607 | 19.6708 | 15.6298 | 13.3994 | 9.9383 | 2.8138 | 2.9118 | 3.1374 |
| 0-A-NS | 30.3086 | 29.2844 | 27.6751 | 26.7747 | 25.7030 | 24.7564 | 25.6553 | 28.0513 | 26.6427 | 28.6085 | 30.8081 | 33.8070 | 37.3635 | 40.4356 | 44.8073 | 46.7191 | 48.6499 | 50.5620 | 49.9563 | 44.3308 | 41.9048 | 37.4643 | 34.9103 | 31.2156 |
| 0-B-NS | 1.1405 | 0.5047 | 0.5143 | 0.4146 | 0.4734 | 0.6669 | 0.4394 | 3.0976 | 38.8305 | 37.6752 | 36.6123 | 38.7395 | 42.6092 | 51.1209 | 56.8231 | 54.3267 | 48.0413 | 46.0473 | 43.2791 | 41.0516 | 19.6968 | 0.9521 | 0.4740 | 0.5519 |

**Count of Data Points**

| | Hour 0 | Hour 1 | Hour 2 | Hour 3 | Hour 4 | Hour 5 | Hour 6 | Hour 7 | Hour 8 | Hour 9 | Hour 10 | Hour 11 | Hour 12 | Hour 13 | Hour 14 | Hour 15 | Hour 16 | Hour 17 | Hour 18 | Hour 19 | Hour 20 | Hour 21 | Hour 22 | Hour 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-A-S | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 | 514 |
| 1-B-S | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 |
| 0-A-S | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 | 192 |
| 0-B-S | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 |
| 1-A-NS | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 |
| 1-B-NS | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 |
| 0-A-NS | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 |
| 0-B-NS | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 |

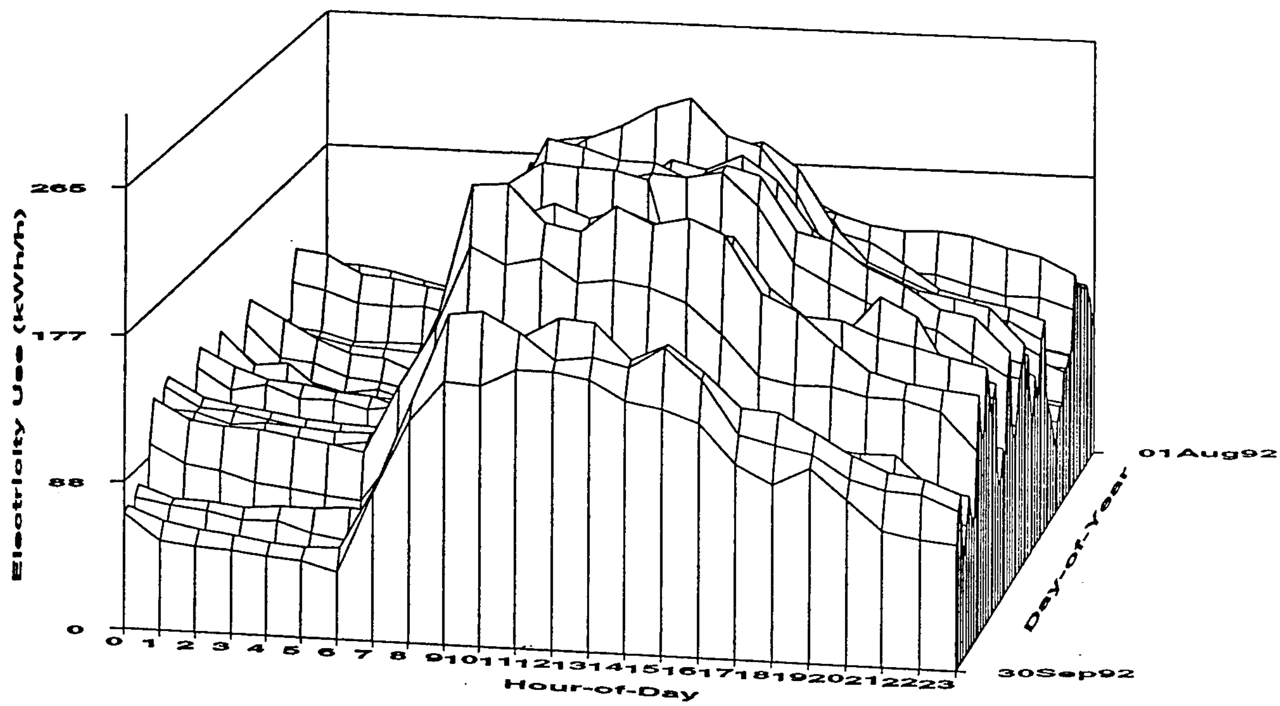
**Key**

| | | |
|---|---|---|
| 1-A-S | = | Semester/Weekday/Pre-Retrofit |
| 1-B-S | = | Semester/Weekday/Post-Retrofit |
| 0-A-S | = | Semester/Weekend/Pre-Retrofit |
| 0-B-S | = | Semester/Weekend/Post-Retrofit |
| 1-A-NS | = | Non-Semester/Weekday/Pre-Retrofit |
| 1-B-NS | = | Non-Semester/Weekday/Post-Retrofit |
| 0-A-NS | = | Non-Semester/Weekend/Pre-Retrofit |
| 0-B-NS | = | Non-Semester/Weekend/Post-Retrofit |

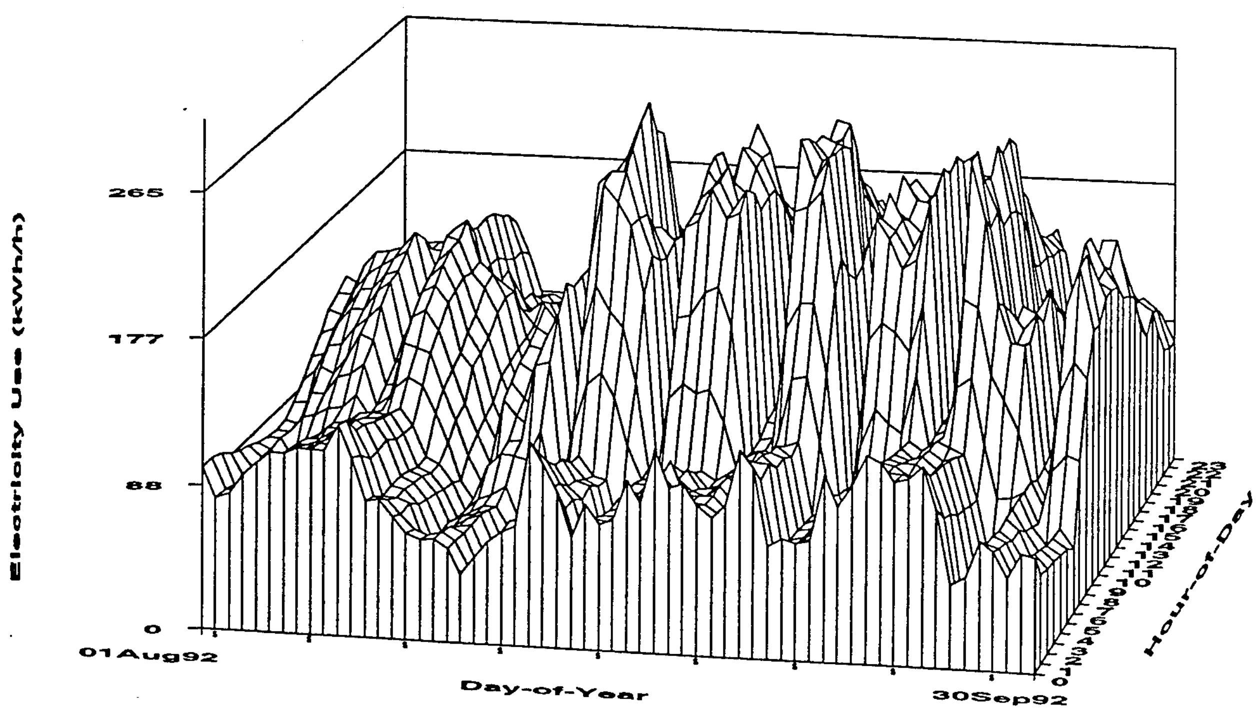
## Tab C-4

## MECR Plots

## Whole–Building Electric

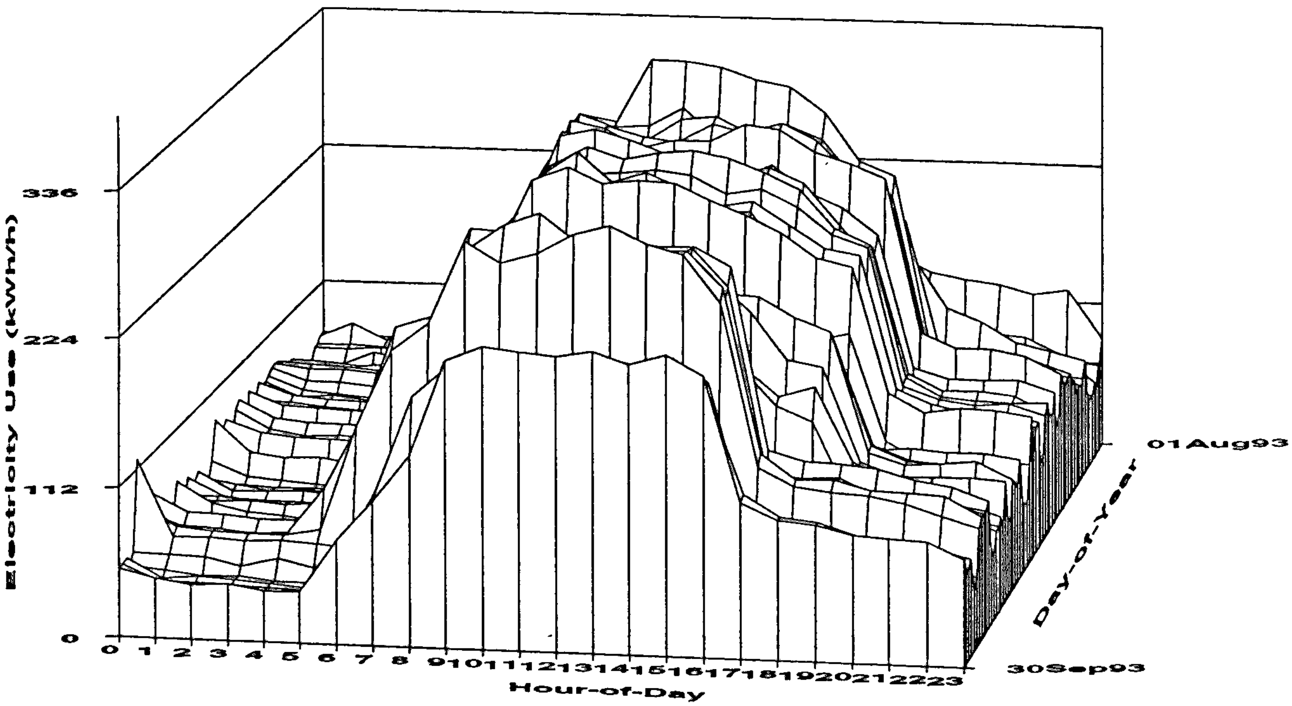



## Whole–Building Electric

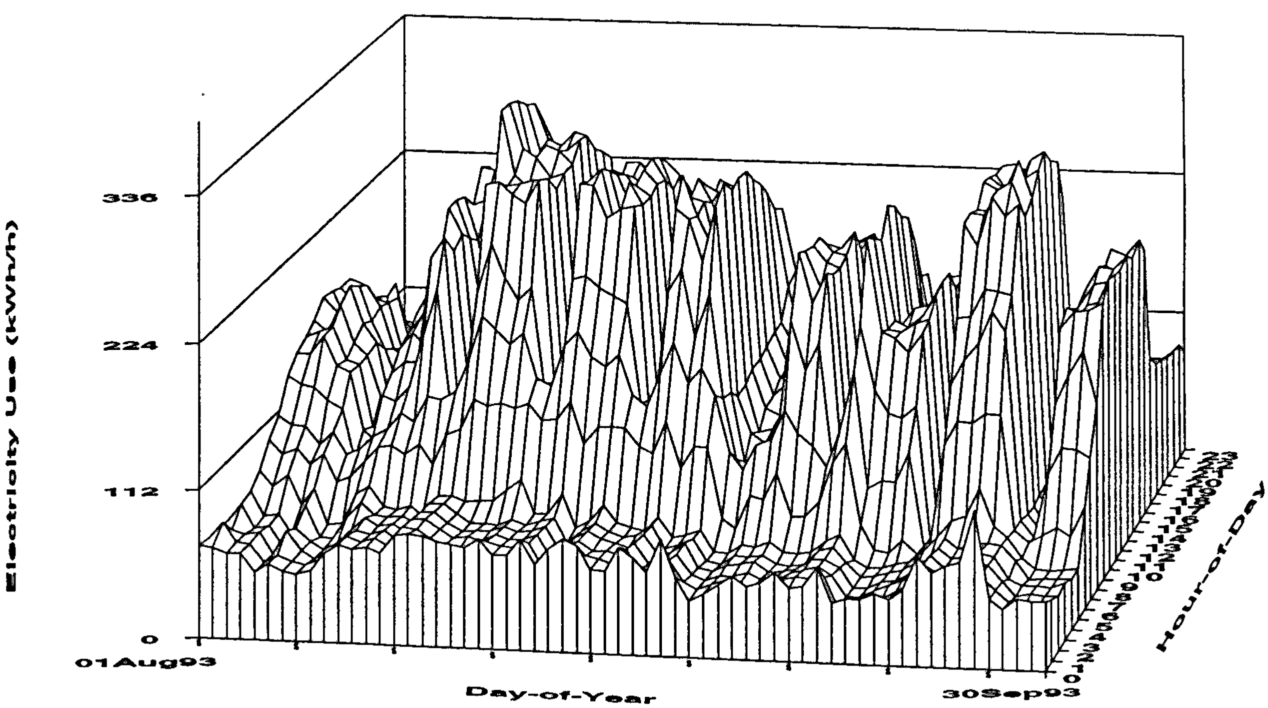



Sundays are marked with an "S"

## Whole–Building Electric

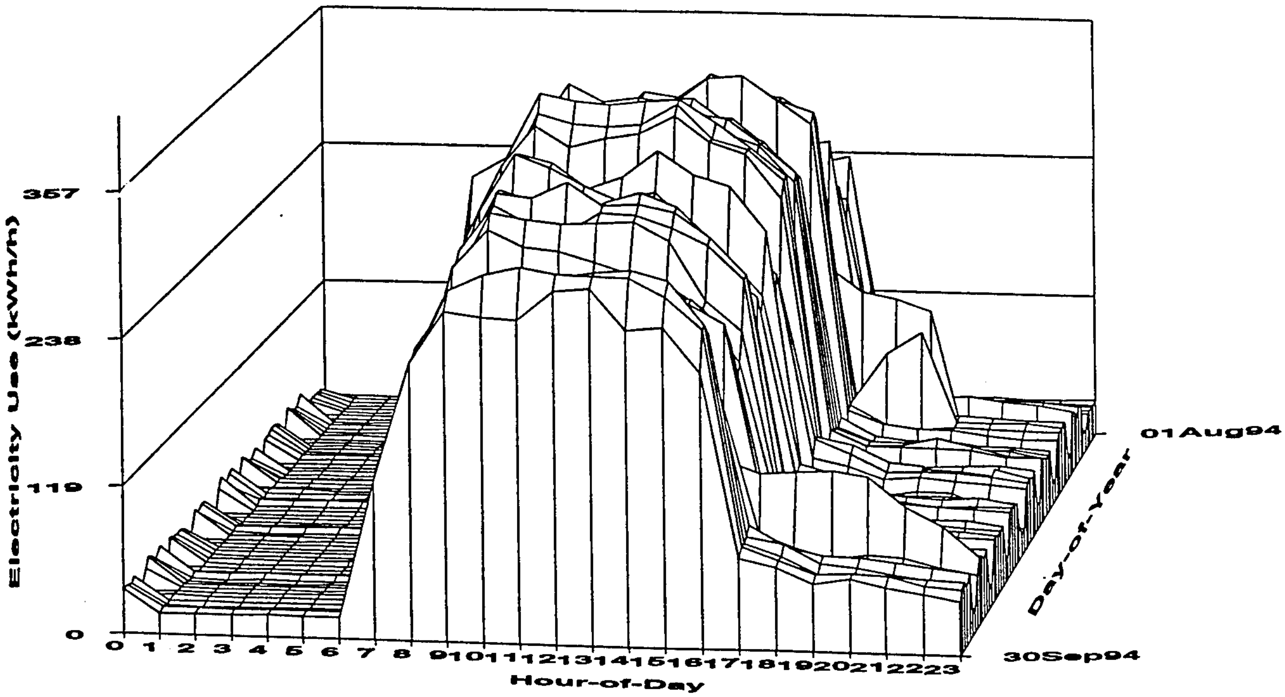



## Whole–Building Electric

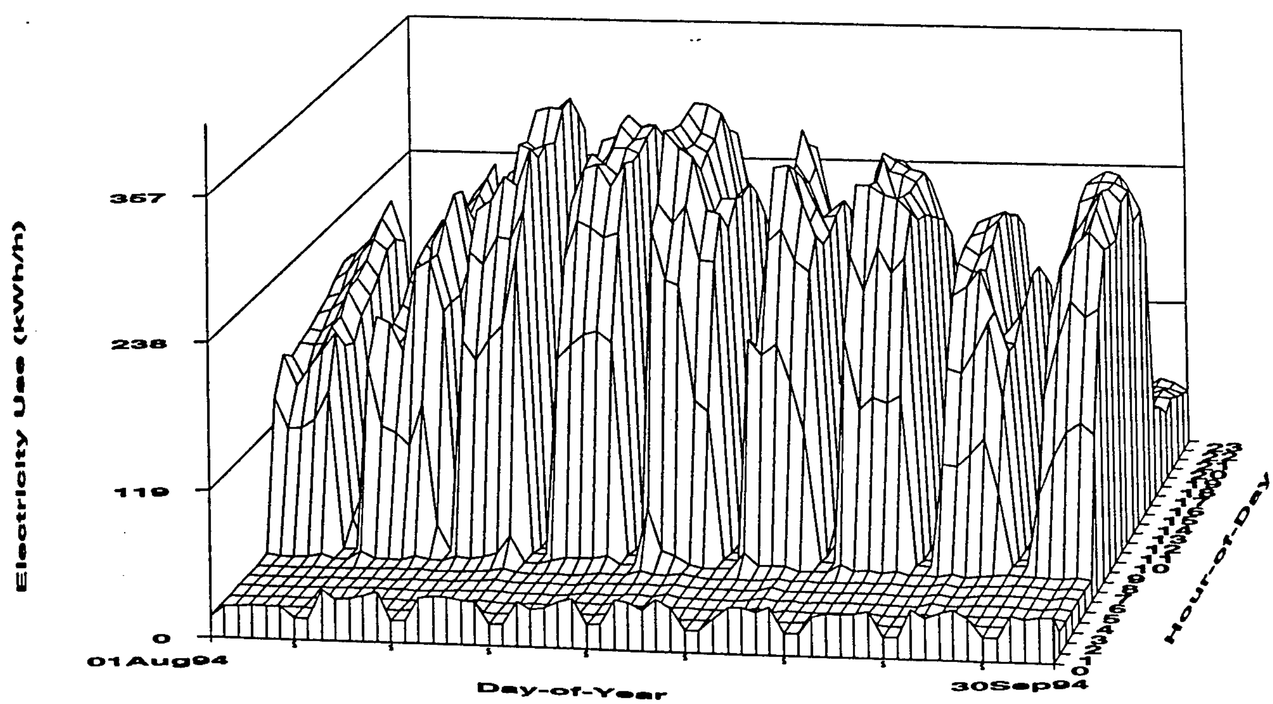



Sundays are marked with an "S"

Whole–Building Electric




Whole–Building Electric




Sundays are marked with an "S"

# Tab C-5

## Data Summary Notebook Information

## FORT WORTH INDEPENDENT SCHOOL DISTRICT

### Sims Elementary School

**Building Envelope:**

- 62,400 sq. ft. built in 1988
- 1-story, walls of face brick, 1/2" scathing on 6" studs, 5/8" gypsum board, and 10" concrete.
- roof built-up with tar and gravel
- windows are single pane, operable, both tinted and clear

**Building Schedule:**

- 7:00 am to 5 pm (M-F) closed (Sat./Sun.)
- 3 months summer break, 18+5 other holidays

**Building HVAC and Equipment**

- About 54 rooftop units (mostly 2/4 to 1/2 ton)
- 2 hot water heaters each 270,000 Btu/hr
- 9 1/2 hpe a exhaust fans

**Lighting**

- Mostly fluorescent (40 W), few PL-13 lamps

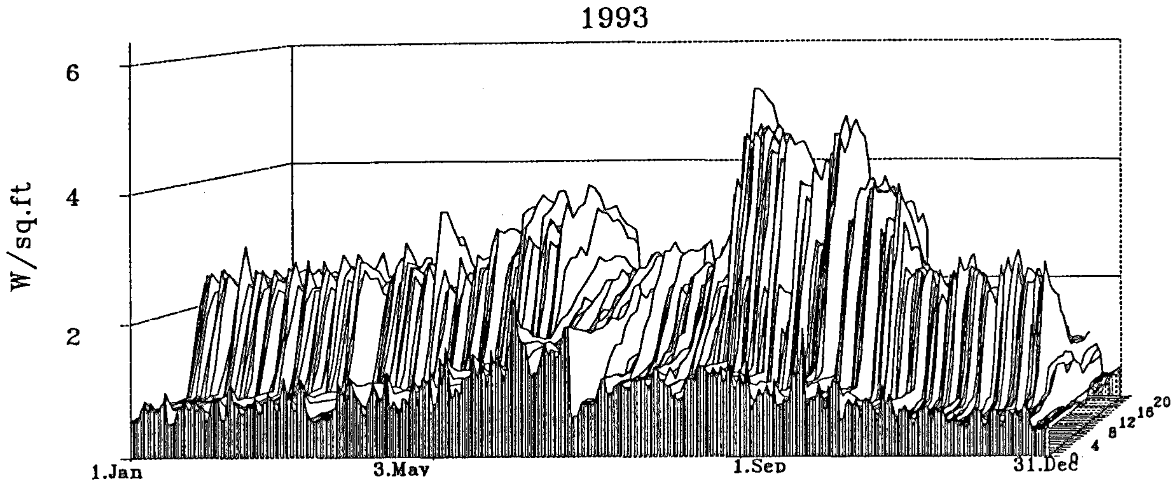
**Proposed Retrofits**

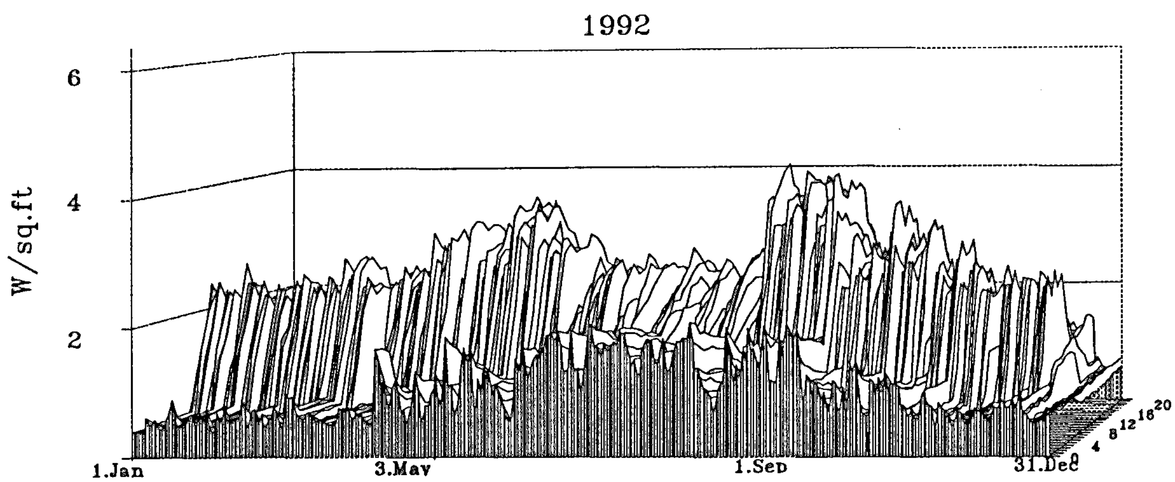
- Convert 2 X 4, 4 lamp fluorescent light fixtures to 2 X 4, 2 lamp configuration to reduce energy consumption for lights by 50

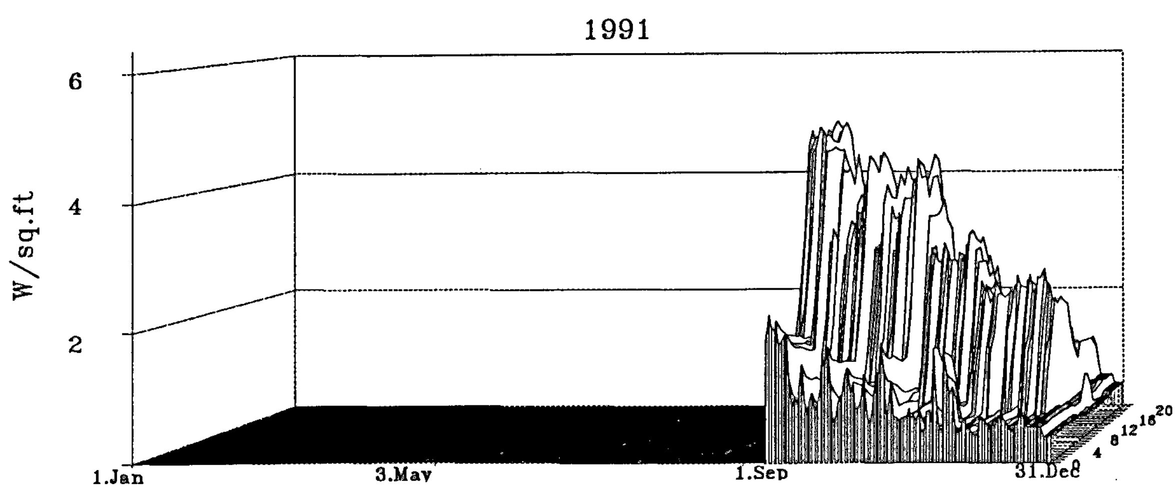
**Completion Data of Report:**

- Lighting modification was completed in November 91.

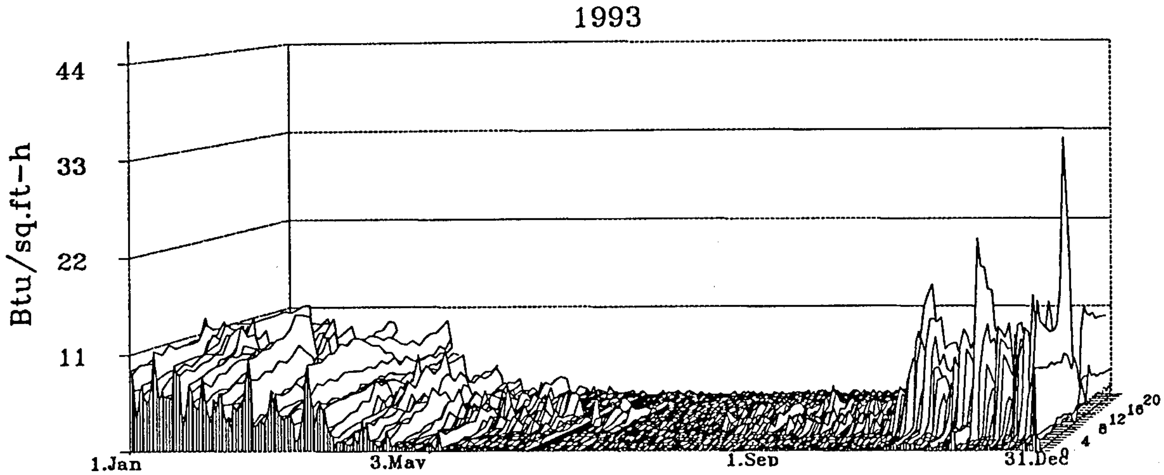
# Sims Elementary School (SIM)
# W.B. Electric as W/sq.ft.

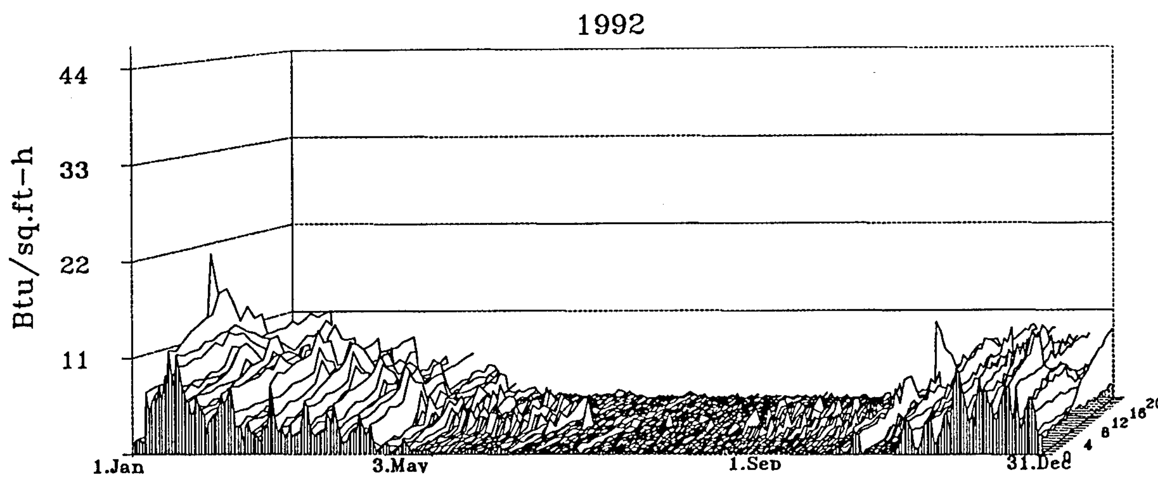


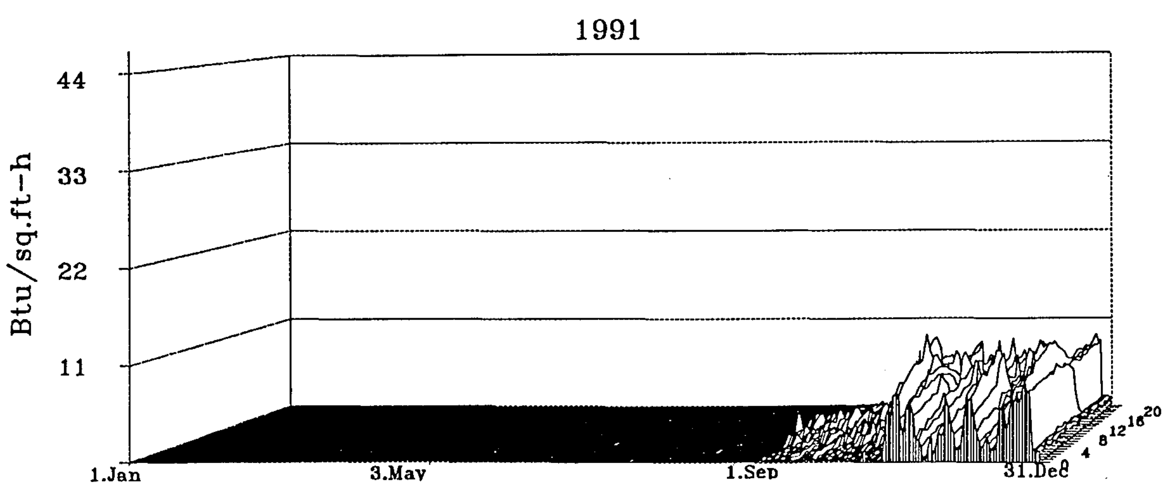



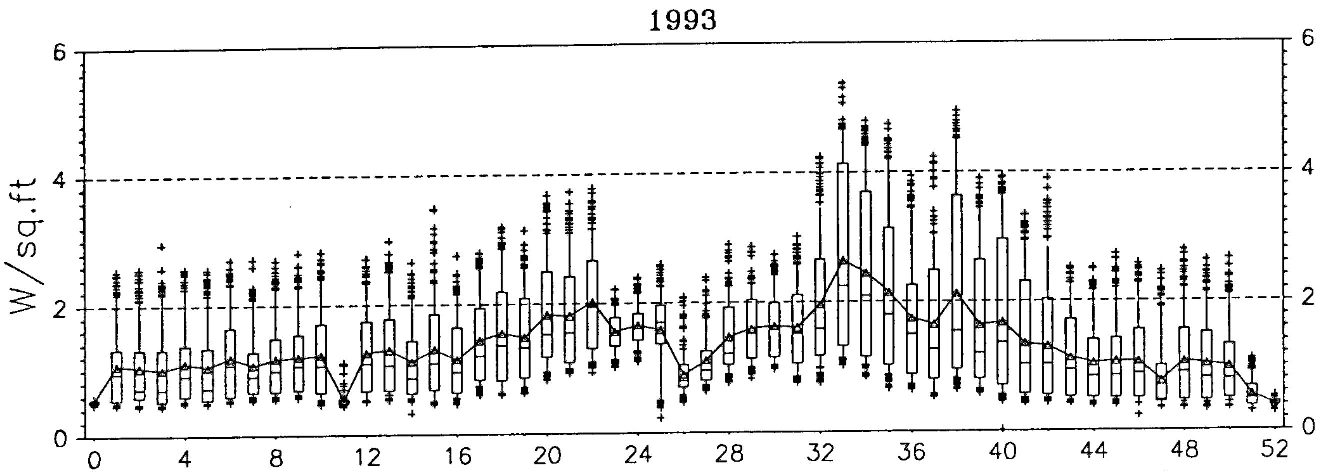
# Sims Elementary School (SIM)
# W.B. HW as Btu/sq.ft.-h

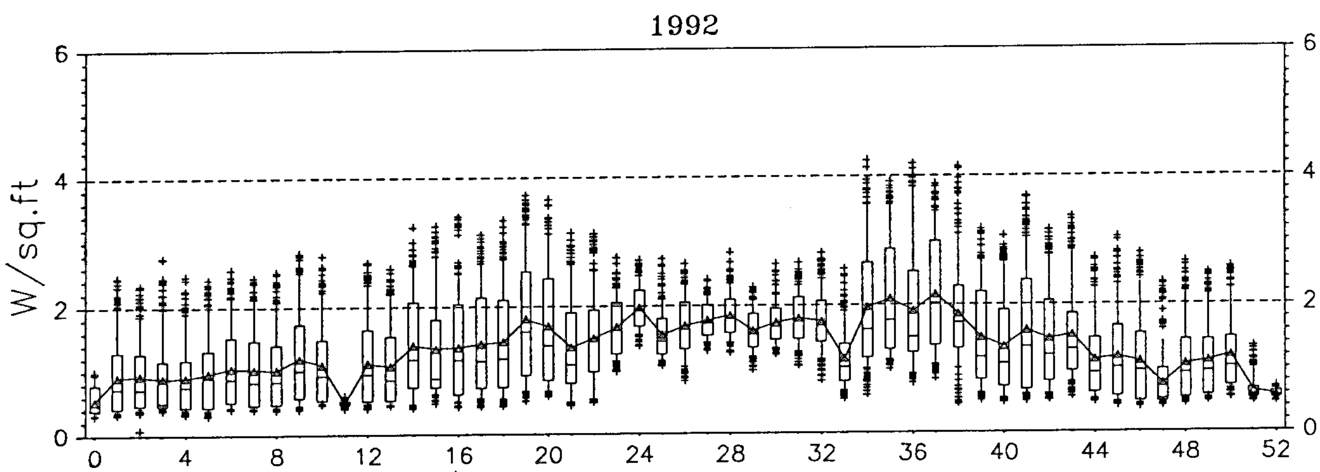


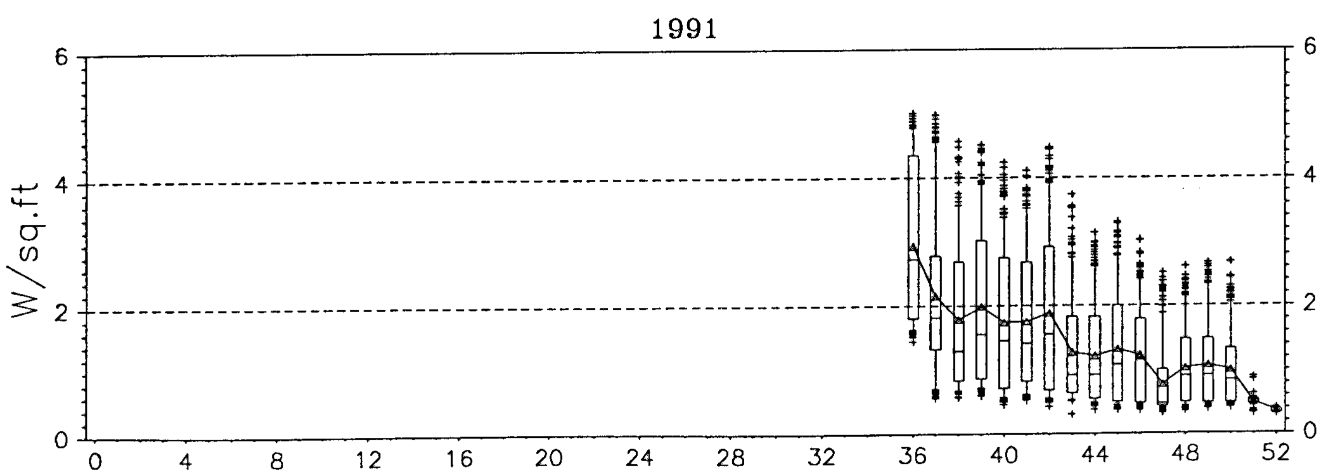



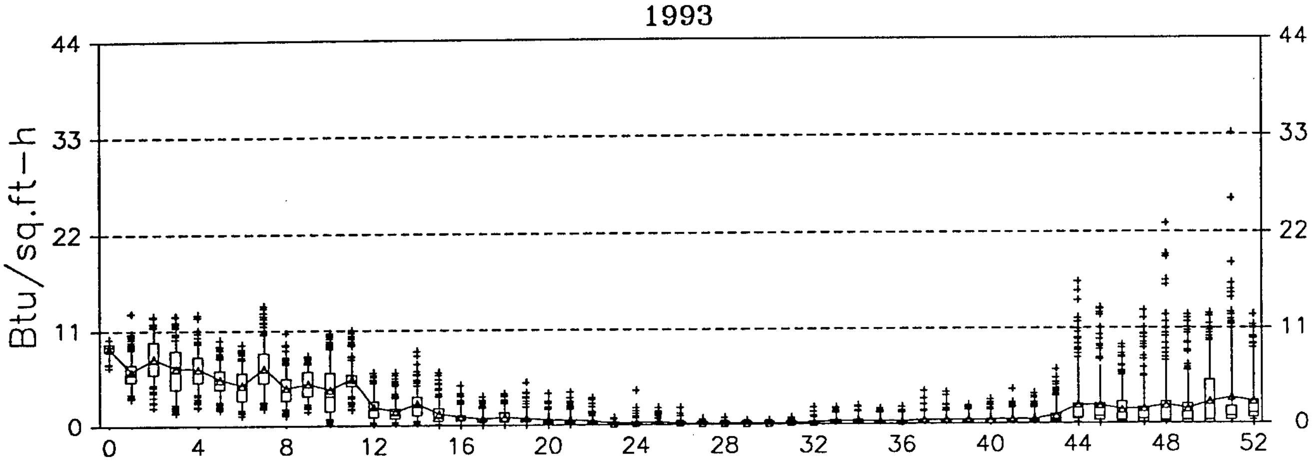
# Sims Elementary School (SIM)
# W.B. Electric as W/sq.ft.

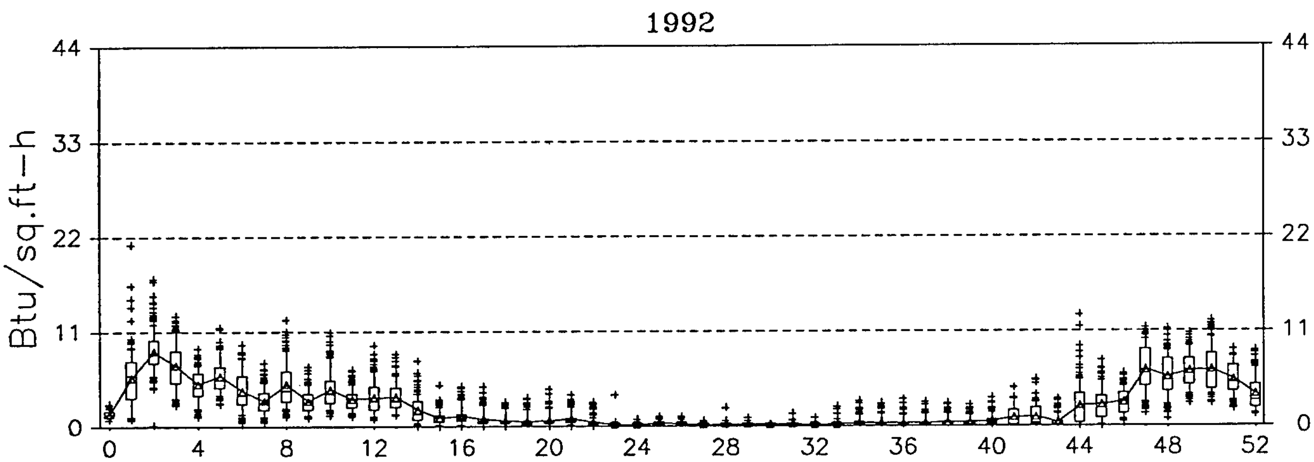


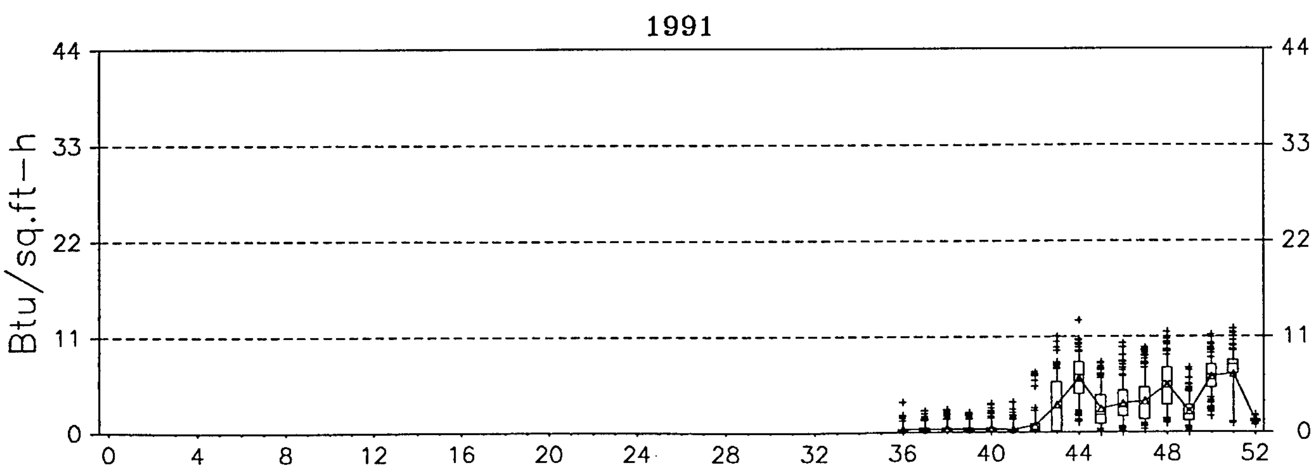



# Sims Elementary School (SIM)
# W.B. HW as Btu/sq.ft.-h



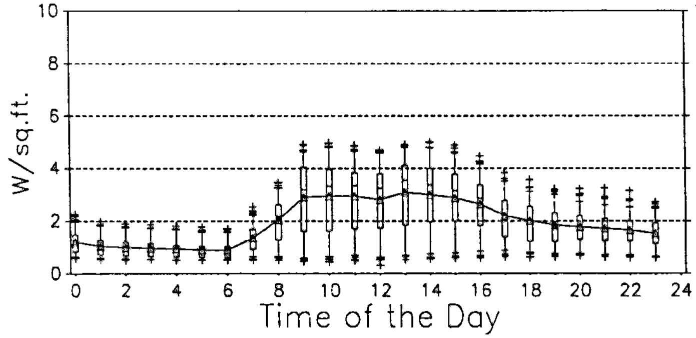



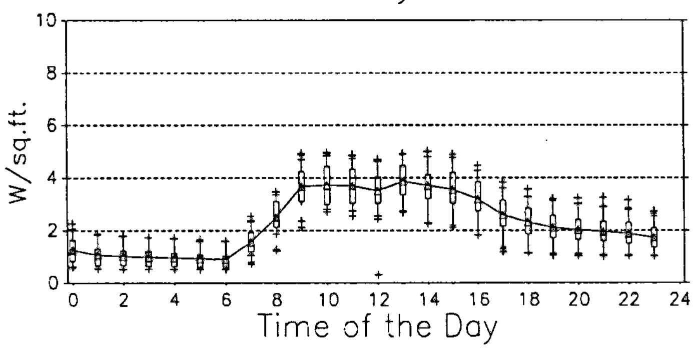
# Sims Elementary School (SIM)
# W.B. Electric as W/sq.ft.

## Pre-Retrofit (09/10/1991 - 11/01/1991)

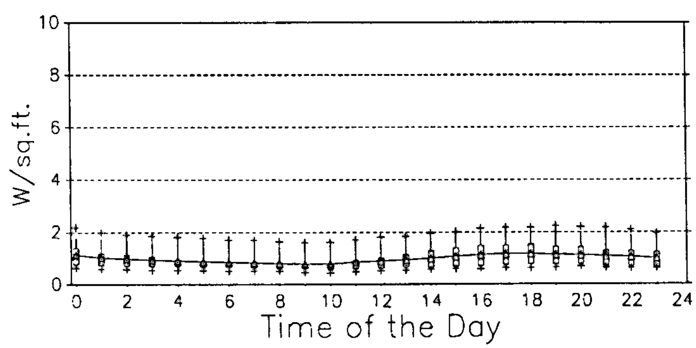
### Everyday




### Weekdays

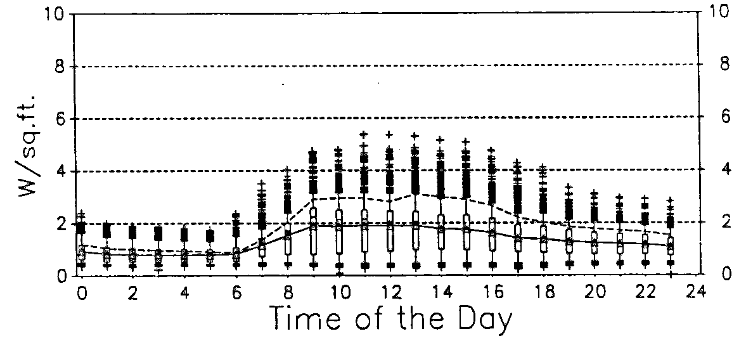



### Weekends

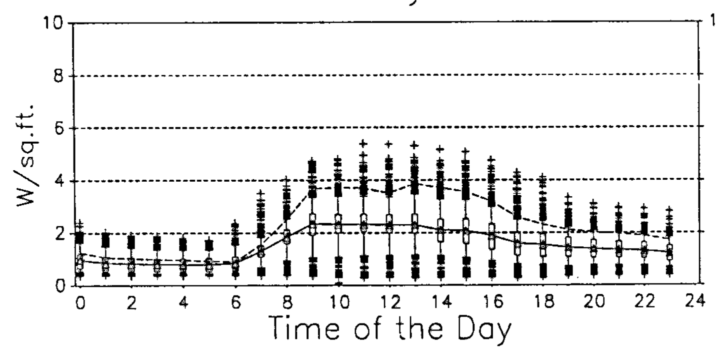



## Post-Retrofit (11/23/1991 - 12/31/1993)

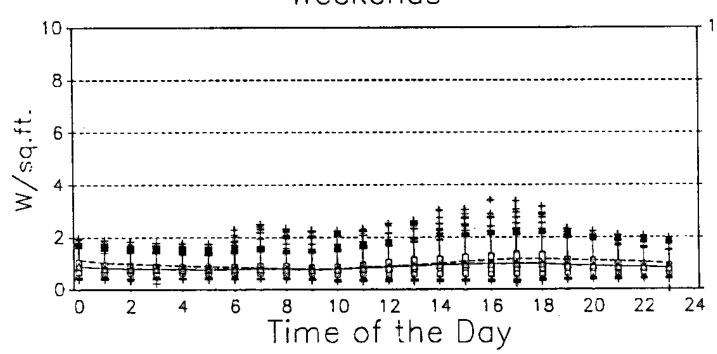
### Everyday




### Weekdays



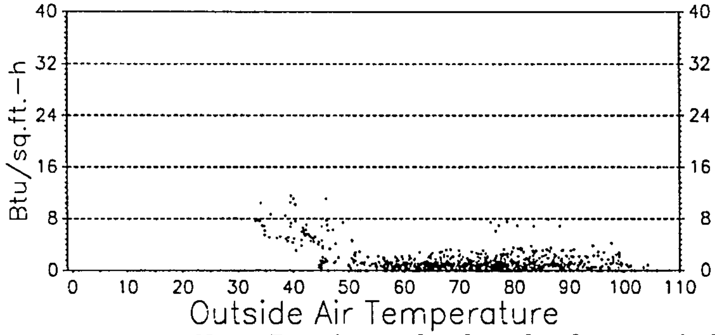

### Weekends



# Sims Elementary School (SIM)
# W.B. HW as Btu/sq.ft.-h

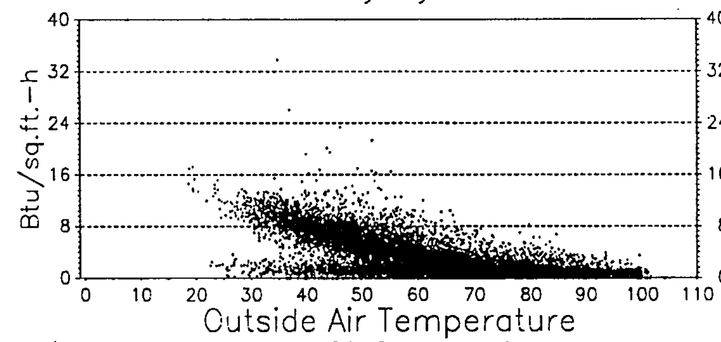
## Pre-Retrofit (09/10/1991 - 11/01/1991)

Everyday



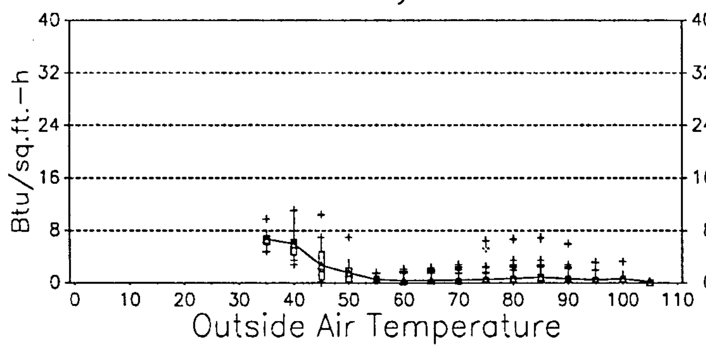

## Post-Retrofit (11/23/1991 - 12/31/1993)

Everyday

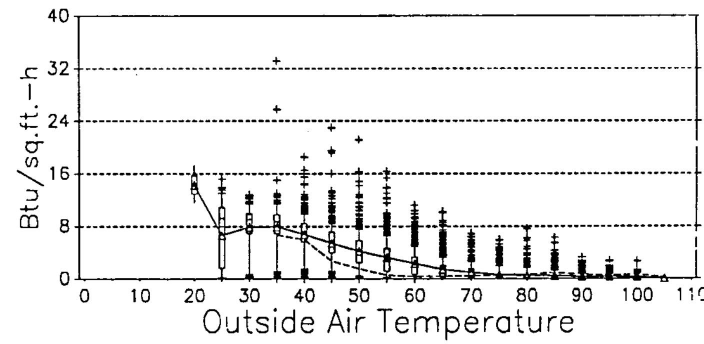



**Note: Data in graphs above has been vertically offset randomly up to 1 Btu/sq.ft.-h to improve graphical presentation.**

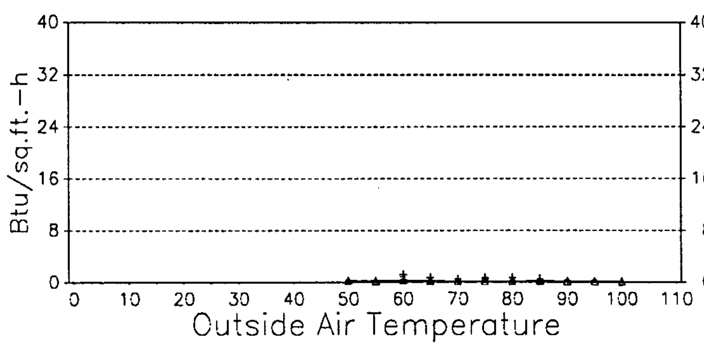
Weekdays



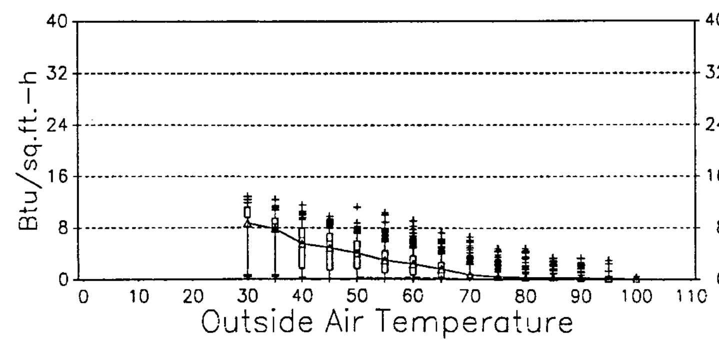

Weekdays




Weekends

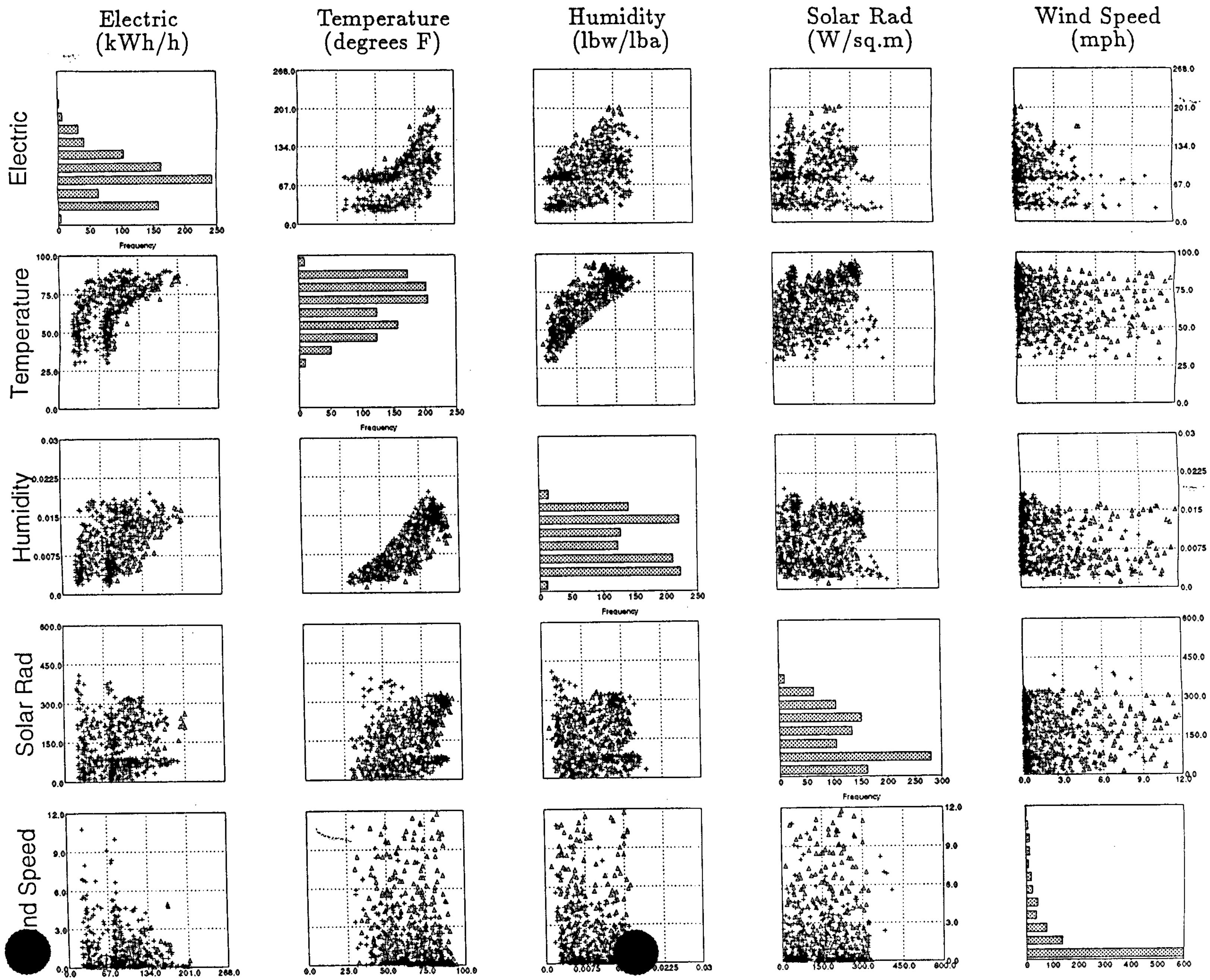



Weekends



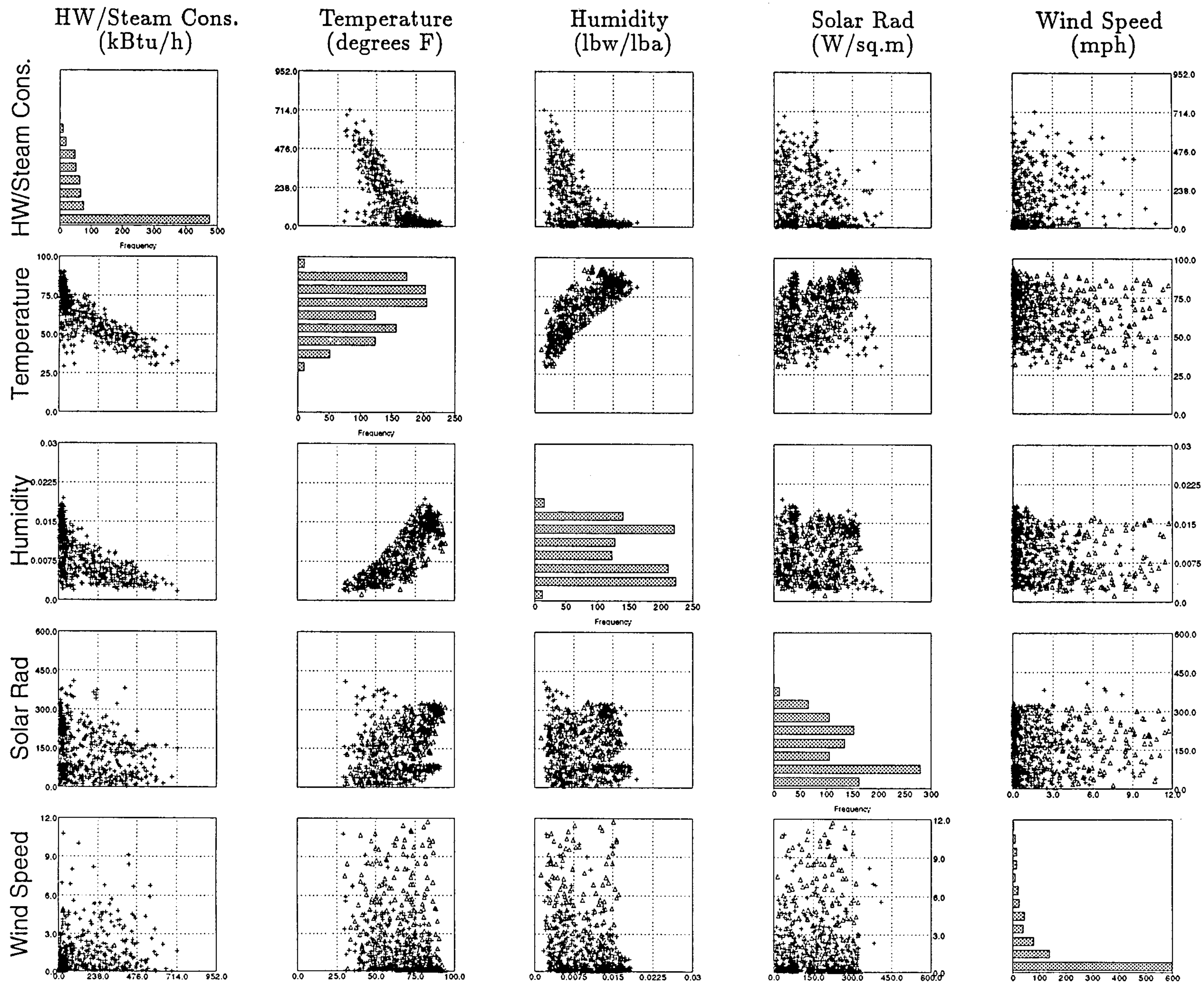
# Sims Elementary School (SIM)
## Daily Average Values

Pre-Retrofit (△) 09/10/1991 - 11/01/1991 Post-Retrofit (+) 11/23/1991 - 12/31/1993



# Sims Elementary School (SIM)
## Daily Average Values

Pre-Retrofit (Δ) 09/10/1991 - 11/01/1991 Post-Retrofit (+) 11/23/1991 - 12/31/1993



# D. ZACHRY ENGINEERING CENTER

## *D.1 Site Description*

The Zachry Engineering Center is located on the north side of Texas A&M University in College Station, Texas. The 3-1/2 story structure includes 324,400 square feet of conditioned space. The main functions of the building are classrooms, laboratory research, and staff offices. All HVAC systems are operated 24 hours/day, 7 days/week, year round. The building activity is very large during regular hours (6:30 a.m. to 5:30 p.m.) and slows down to a moderate pace after hours and on weekends.

Energy using systems include: chilled water, hot water, domestic hot water, and electricity. These services are provided by the Main Campus Central Plant via an underground tunnel. There are several types of air distribution systems in the building. The main system that serves 90% of the building is a double duct variable air volume arrangement, with twelve major and some smaller air handling units located along the periphery of the basement parking garage. Each of the major AHUs is equipped with a 40 horsepower supply fan, and is serving portions of the three floors.

A site summary sheet from the September 1994 MECR is included in Tab D-1. The monitoring diagrams are included in Tab D-2.

## *D.2 EMCS Retrofit*

The audit did not make a separate recommendation for an EMCS retrofit. An EMCS to control HVAC was installed along with the recommended retrofits for this site in March of 1991. The EMCS controls the HVAC by controlling the fan speed and nighttime setbacks. The fan speed is controlled according to the demand for cooling in a particular zone. If the occupancy of a zone drops, then there is not as great of a heat load, and the fan speed slows down, thereby providing a lesser amount of cold air to that room. The nighttime setback involves changing the thermostat setpoints to a higher temperature during nighttime hours, when occupancy is greatly reduced.

## *D.3 Analysis*

### D.3.1 Data Summary Notebook[1]

The Data Summary Notebook was prepared by the Monitoring and Analysis Task of the Texas LoanSTAR program. Is was prepared to provide a historical look at all the data that have been collected for all of the LoanSTAR sites. The data are displayed in several graphical forms to show different aspects of the energy consumption behavior of a building both before and after the retrofit. These plots are analyzed for this site as a means to compare them to those prepared for the other study sites.

#### *D.3.1.1 3-D Surface Plots*

The 3-D surface plots for this site are shown in Tab D-3. The 3-D surface plots are generated using SAS[2] graphics and are displayed to show hourly data over several years. The plots show the whole building (WB) energy consumption, the total electricity consumption by motor control centers (MCC), and the whole building thermal energy use in one plot per year. The 3-D surface plots show the hours in a day on the X axis (into the page), the days of the year from left to right on the horizontal Y-axis in front of the plot, and the variable itself is the height of the plot above the X-Y plane. The plot, in effect, becomes a compilation of 365 daily 24 hour profiles.

<u>Observations</u>: A noticeable reduction in whole building electricity consumption can be seen at the retrofit date of March 1991. No comment can really be made about the hour of day axis, as it is very difficult to read, and it shows up on the pre/post, weekday/weekend, 24 hour BWM plots. A much more significant reduction is evident in the plots for the Motor Control Center (from approximately 380 kWh/h to approximately 200 kWh/h). The daily profile changes from basically constant consumption to low nighttime consumption with higher daytime consumption. Again, this is hard to read on this plot. As chilled water and hot water usage were not studied in the other test sites, no comparisons with other sites can be made. However, the plots are included for completeness.

---

[1] Data Summary Notebook for Site 001, Zachary Engineering Center
[2] Base SAS Software, SAS Institute, Inc., Cary NC 27512-8000

Comparison: For the other study sites, 2-D energy consumption plots were used to show daily consumption versus day of the year. The hourly consumption was averaged over certain sort parameters and plotted as hourly consumption versus hour of day.

### *D.3.1.2 Weekly Box Whisker Mean (BWM) Plots*

Weekly Box Whisker Mean Plots for this site are shown in Tab D-4. The weekly BWM plots are arranged in the same manner as the 3-D surface plots to facilitate a comparison between pages. To generate the weekly BWM plots, the data are first grouped into 52 weeks. Each week starts on a Sunday and ends on a Saturday. The BWM symbol efficiently displays the means, the 10th, 25th, 50th, 75th, and the 90th percentiles and all the outliers above the 90th percentile and below the 10th percentile. The box extends from the 25th (first quartile) to the 75th (third quartile) percentile. The whiskers extend from the top of the box to the 90th percentile and from the bottom of the box to the 10th percentile. The median (50th percentile) is marked inside the box with a single cross hatch. Values less than the 10th percentile and greater than the 90th percentile are marked as pluses (+), which lie below or above the whiskers. Means for each week are superimposed as triangles and joined by a line.

Observations: As would be expected, the weekly consumption also drops at the retrofit date of March 1991. More information is provided in these plots than in the 3-D surface plots. Here, statistical data is included in the form of BWM plots.

Comparison: Weekly data was not analyzed in the other sites.

### *D.3.1.3 Pre/Post, Weekday/Weekend, 24-hour BWM Plots*

The pre/post, weekday/weekend, 24 hour BWM plots for this site are shown in Tab D-5. To generate these plots, the data are first separated into pre-retrofit and post-retrofit periods. Within each period, the data are grouped into weekdays and weekends. The whole building electricity (WB Electric) consumption, as W/sf, is plotted as 24-hour BWM plots against the time of the day for: (1) each day (regardless of weekdays or weekends), (2) weekdays only, and (3) weekends only for both the pre-retrofit and the post-retrofit periods. In addition, the mean lines from the pre-retrofit panels are superimposed as dashed lines on the post-retrofit panels to show the changes in the hourly profiles due to the retrofit.

Observations: In all three plots (everyday, weekdays and weekends), a reduction in whole building electricity is evident. In each post-retrofit plot, the line connecting the means of each data point is below the superimposed pre-retrofit line (dashed line). The reduction is fairly constant across all hours of the day.

Comparison: There are a number of differences between these plots and the hourly average plots used for the other sites. First, there is an additional category in the average hourly plots, which is semester/non-semester. This is an important sort category because for many sites, the average consumption during the semester periods varies greatly from the average consumption during the non-semester periods. As consumption is different between these two periods, it is useful to study them separately. Secondly, the consumption units are different (W/sf for BWM plot versus kWh/h for the average hourly consumption plots. It is useful to convert the units to W/sf for the sake of comparing with other sites, which may be significantly different in size. Lastly, the BWM plot is more effective in showing the statistical variation in the data, but it is also difficult to read.

### *D.3.1.4 Pre/Post, Weekday/Weekend, BWM Temperature Binned Plots*

The pre/post, weekday/weekend, BWM temperature binned plots for this site are shown in Tab D-6. For thermal loads, such as the chilled water consumption and steam/hot water consumption, the weekday and weekend energy consumption is grouped into 5 °F temperature bins and plotted as BWM plots against the ambient temperature. These same data are also plotted as scatter plots to show the general trend and density of the data points. The data for the scatter plots are slightly jittered to improve graphical presentation. Jittering is a graphical enhancement that improves a plot by adding a random noise to one of the variables. Jittering is necessary when BTU data are plotted because data are recorded in large increments, which causes severe data overlap when plotted.

Observations: There is a noticeable reduction in whole building chilled water and whole building hot water consumption. Although these were not analyzed in the other study sites, they provide an additional way to view the data.

Comparison: Chilled water and hot water consumption were not studied in the other sites.

### *D.3.1.5 Carpet Plots of Energy Use versus Ambient Conditions with Juxtaposed Histograms*

Carpet plots of energy use versus ambient conditions are shown in Tab D-7. Carpet plots show the daily averaged pre/post data plotted against several variables. Separate symbols are used for the pre-retrofit (triangle) and post-retrofit (plus) periods. The carpet plot is arranged so that relationships between energy consumption and several weather variables (ambient temperature, humidity, global horizontal solar radiation, and wind speed) can be simultaneously viewed. In the carpet plot shown, energy consumption is shown along the top row and the left most column. Other panels show the interaction among the weather variables. The panels along the diagonal show the frequency distribution of all the data points within bins.

Observations: These plots are very small and hard to read, but show various trends in data.

Comparison: No comparisons can be made as these plots are not used for the other study sites.

### *D.3.1.6 Carpet Plots of One Energy Channel Use Against Other Energy Use Channels*

Carpet plots of one energy channel use against other energy use channels are shown in Tab D-8. These are specialty carpet plots where one energy use is plotted against other energy use channels. In the plot shown, lights and receptacle (L&R) electricity use is a derived channel which is obtained by subtracting the MCC electricity use from the whole building electricity use. These carpet plots are helpful in determining interactions between one energy use, such as chilled water consumption, and another, such as steam/not water consumption in both the pre-and post-retrofit periods.

Observations: These plots are very small and hard to read, but show trends in data.

Comparison: No comparisons can be made as these plots are not used for the other study sites.

### *D.3.1.7 Coincident Cumulative Frequency Plots*

Coincident cumulative frequency plots for this site are shown in Tab D-9. The coincident cumulative frequency plot shows the whole building electricity consumption and the coincident electricity consumption by the Motor Control Centers (MCC). To produce these plots, data are first separated into pre- and post-retrofit periods and sorted into descending order of whole building electricity consumption. The data is then plotted from the highest to the lowest consumption along with the coincident MCC electricity consumption. This plot is generally useful to show the drop in whole building and MCC electricity consumption due to a VAV retrofit.

Observations: These plots show a definite decrease in both whole building electricity and MCC electricity consumption.

Comparison: No comparisons can be made as these plots are not used for the other study sites.

## Tab D-1

## Site Summary Sheet

# TEXAS A&M UNIVERSITY

## Zachry Engineering Center

### Building Envelope:
- 324,400 sq.ft
- 3-1/2 floors and a ground floor level, erected 1973, classes, offices, labs, computer facility, and clean rooms for Solid State Electronics
- walls: cement block
- windows: 12% of total wall area
  single pane with built-in-place vertical blinds
- roof: flat

### Building Schedule:
- classrooms and labs: 7:30 am to 6:30 pm weekdays
- offices: 7:30 am to 5:30 pm weekdays
- computer facility: 24 hrs/day

### Building HVAC:
- 12 variable volume dual duct AHUs (12-40hp)
- 3 constant volume multizone AHU (1-1 hp, 1-7hp, 1-10hp)
- 4 constant volume single zone AHU (4-3hp)
- 10 fan coils (10-0.5 hp)
- 2 constant volume chilled water pump (2-30hp)
- 2 constant hot water pump (2-20hp)
- 7 misc. pumps (total of 5.8hp)
- 50 exhaust fans (50-0.5hp)

### HVAC Schedule:
- 24 hrs/day

### Lighting:
- fluorescent

### Retrofits Implemented:
- control modifications to the dual duct system
- variable volume dual duct system

### Other Information:
- EMCS system to control HVAC was also installed along with the retrofits.

### Date of Retrofits:
- date of completion for VAV and control modifications to the dual duct system: 03/05/91.

### Savings Calculations:
- estimated savings are average monthly savings from the audit report (total annual savings divided by 12).

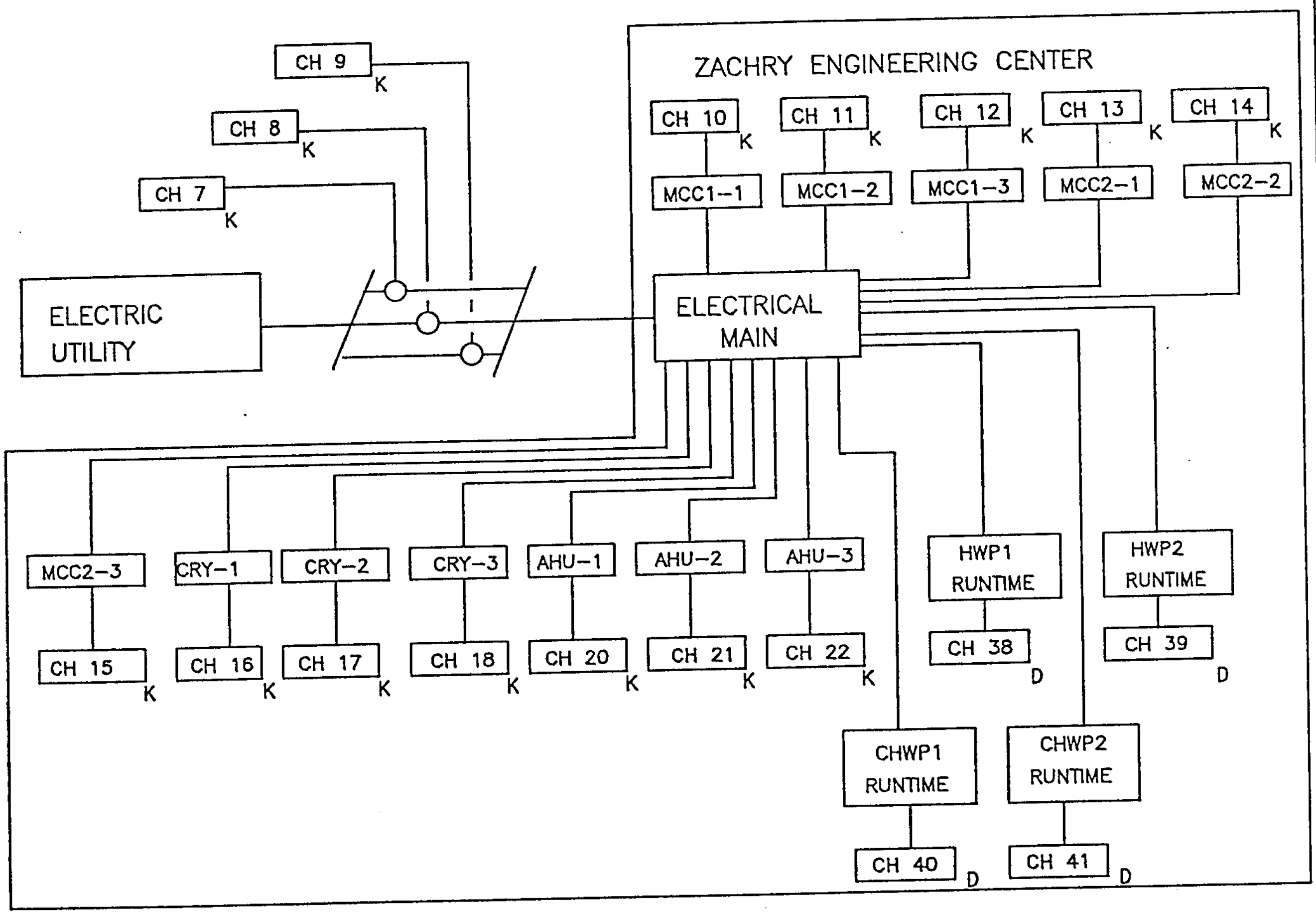
## Tab D-2

## Monitoring Diagrams

# ELECTRICAL MONITORING DIAGRAM
## ZACHRY ENGINEERING CENTER

LEGEND

K=KWH CHANNEL
A=ANALOG CHANNEL
D=DIGITAL CHANNEL



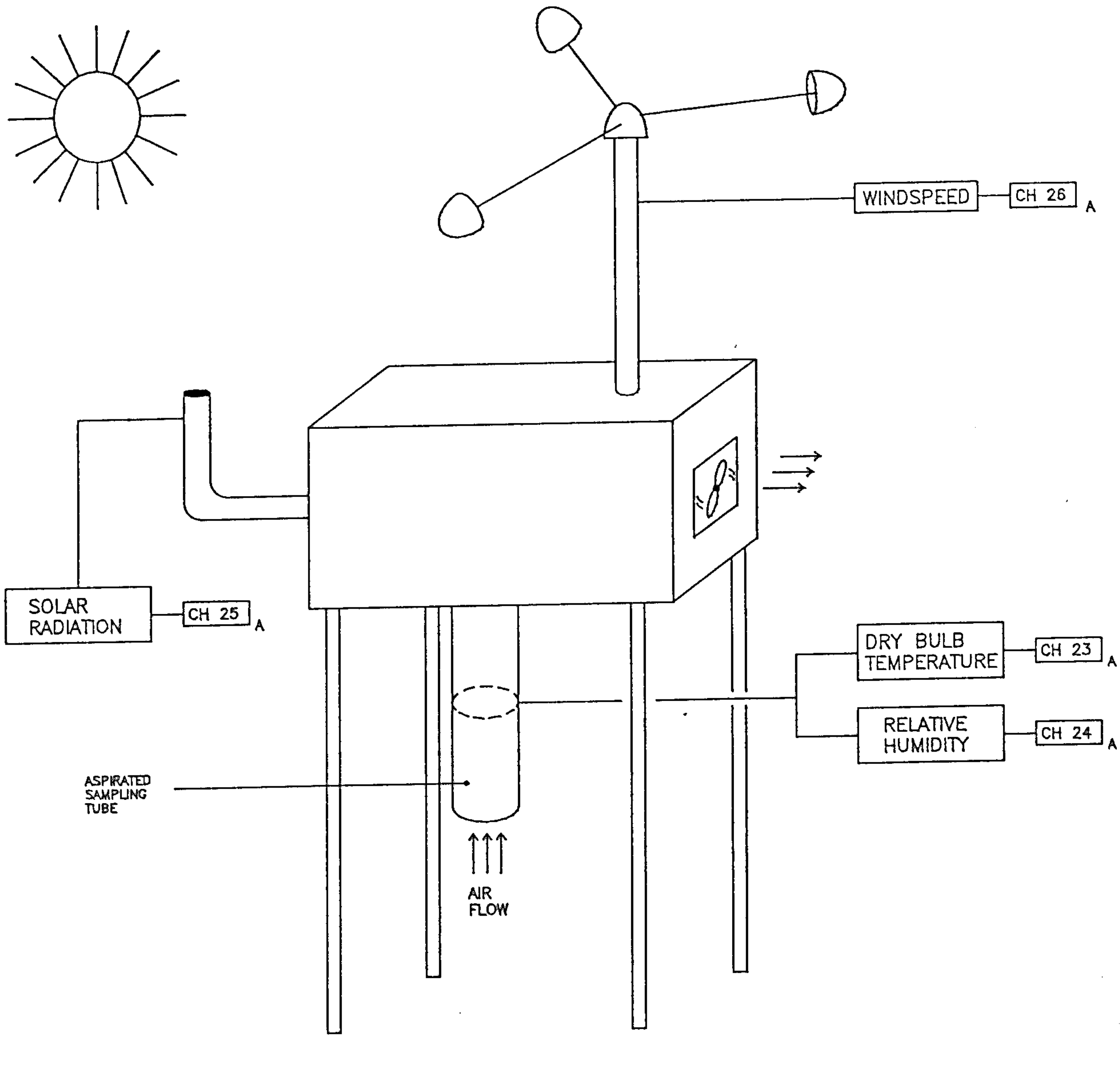

ZACHRY ENGINEERING CENTER — SITE 001

received 7-7-93

# WEATHER MONITORING DIAGRAM
## ZACHRY ENGINEERING CENTER

LEGEND

K=KWH CHANNEL
A=ANALOG CHANNEL
D=DIGITAL CHANNEL
PC=PUMPED CONDENSATE



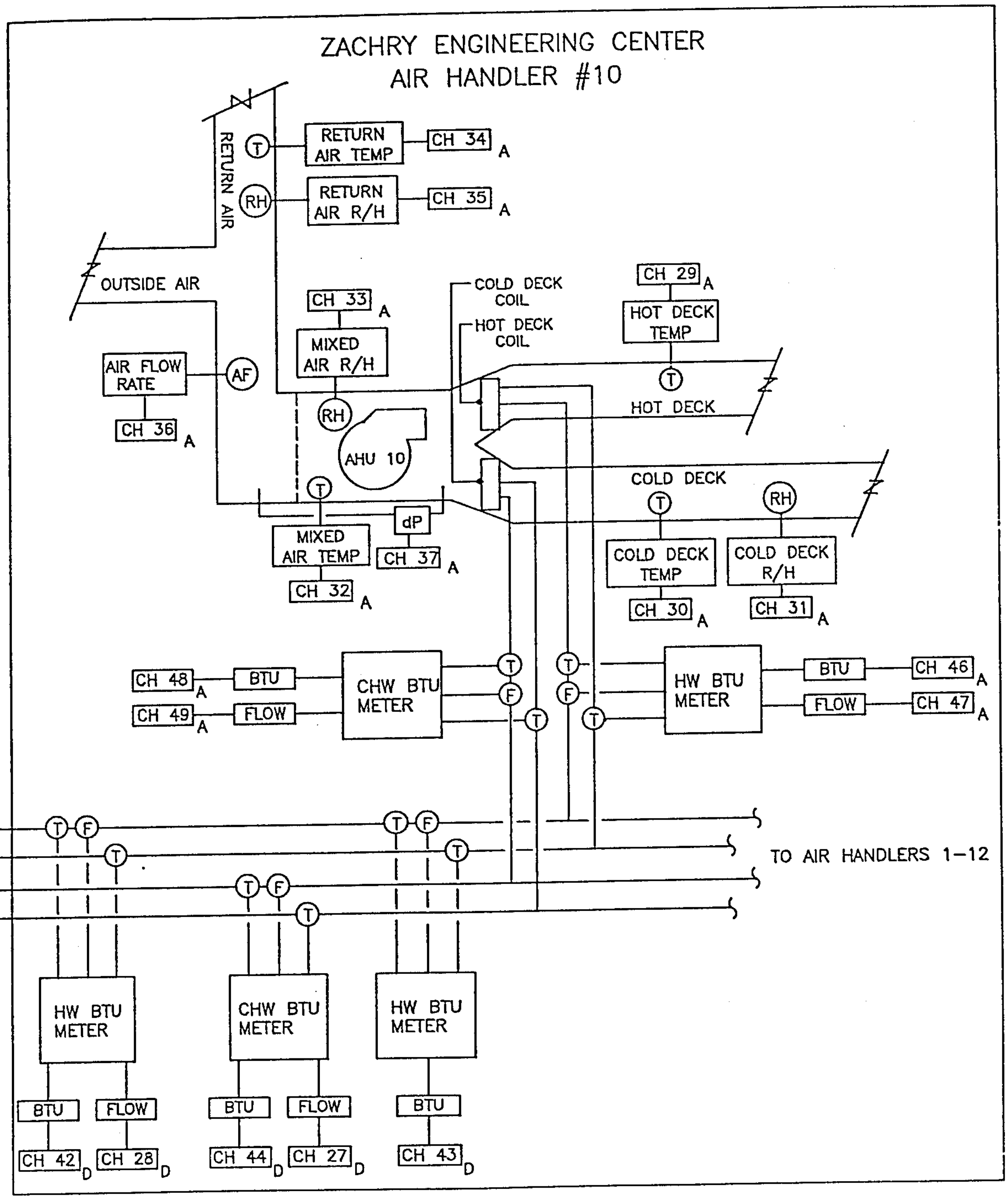

ZACHRY ENGINEERING CENTER – SITE 001

# THERMAL MONITORING DIAGRAM

## ZACHRY ENGINEERING CENTER

LEGEND

K–KWH CHANNEL
A–ANALOG CHANNEL
D–DIGITAL CHANNEL
PC–PUMPED CONDENSATE




ZACHRY ENGINEERING CENTER – SITE 001

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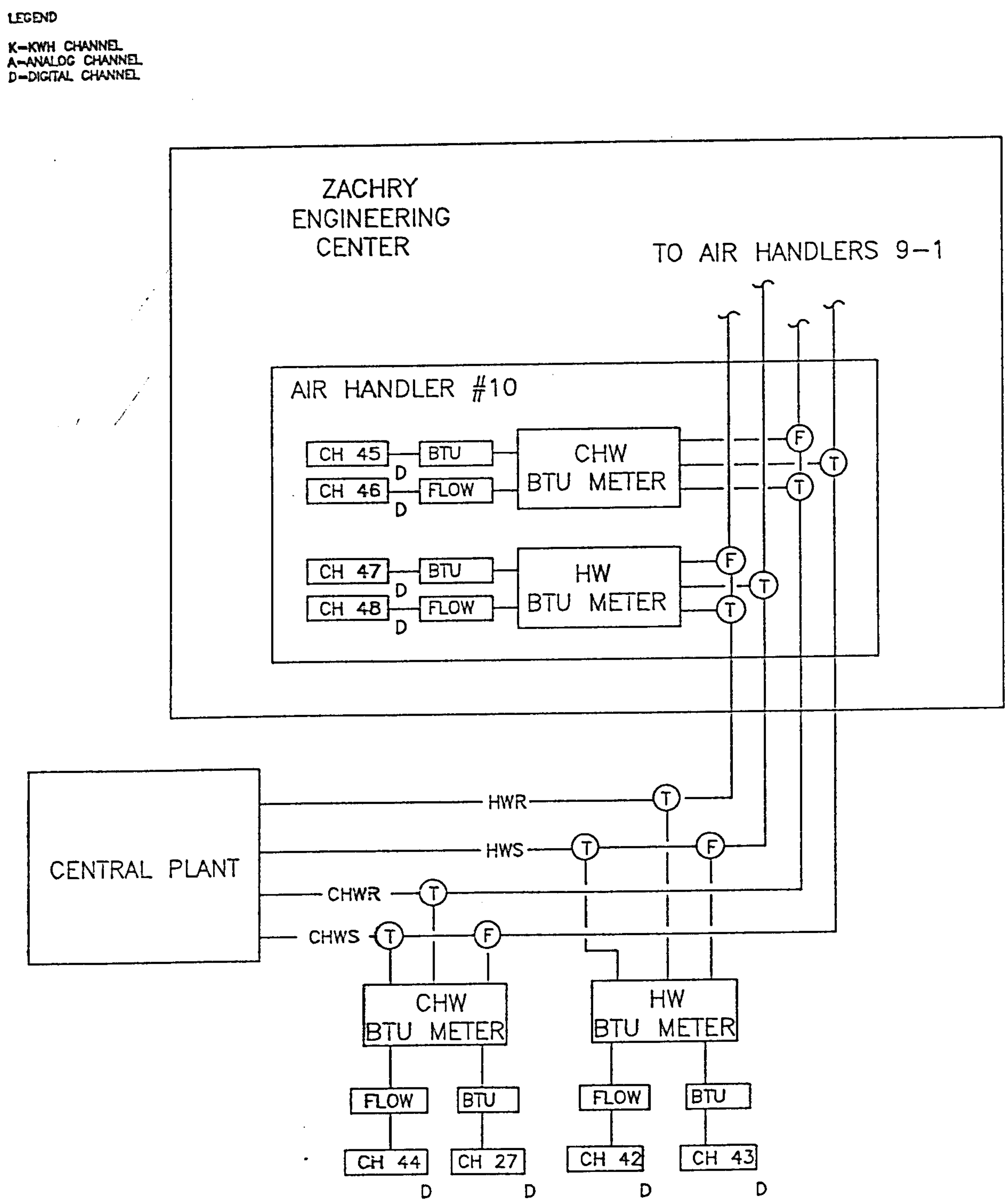
7-6-93

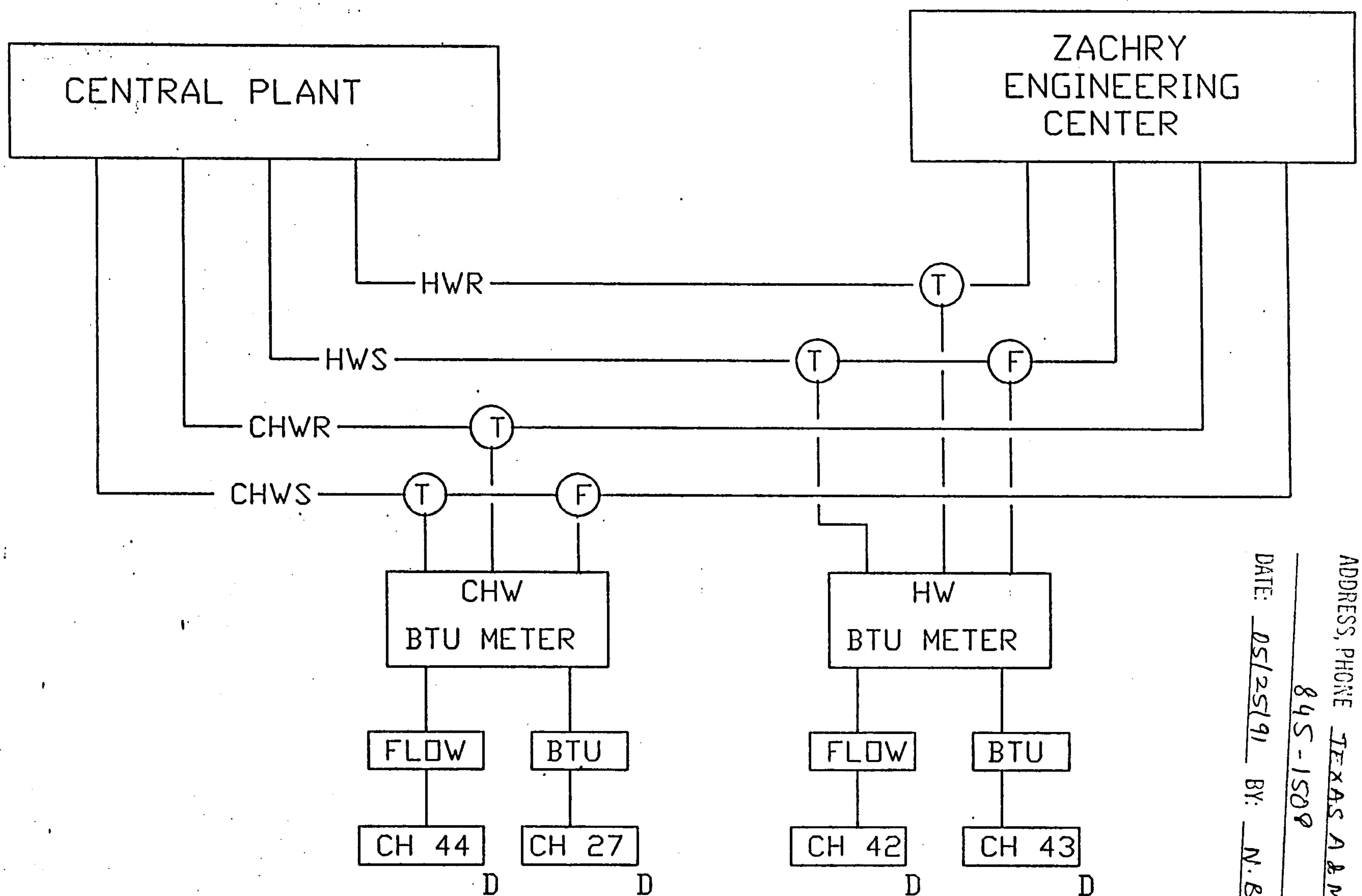
# THERMAL MONITORING DIAGRAM
## ZACHRY ENGINEERING CENTER




ZACHARY ENGINEERING CENTER – SITE 001

# THERMAL MONITORING DIAGRAM A

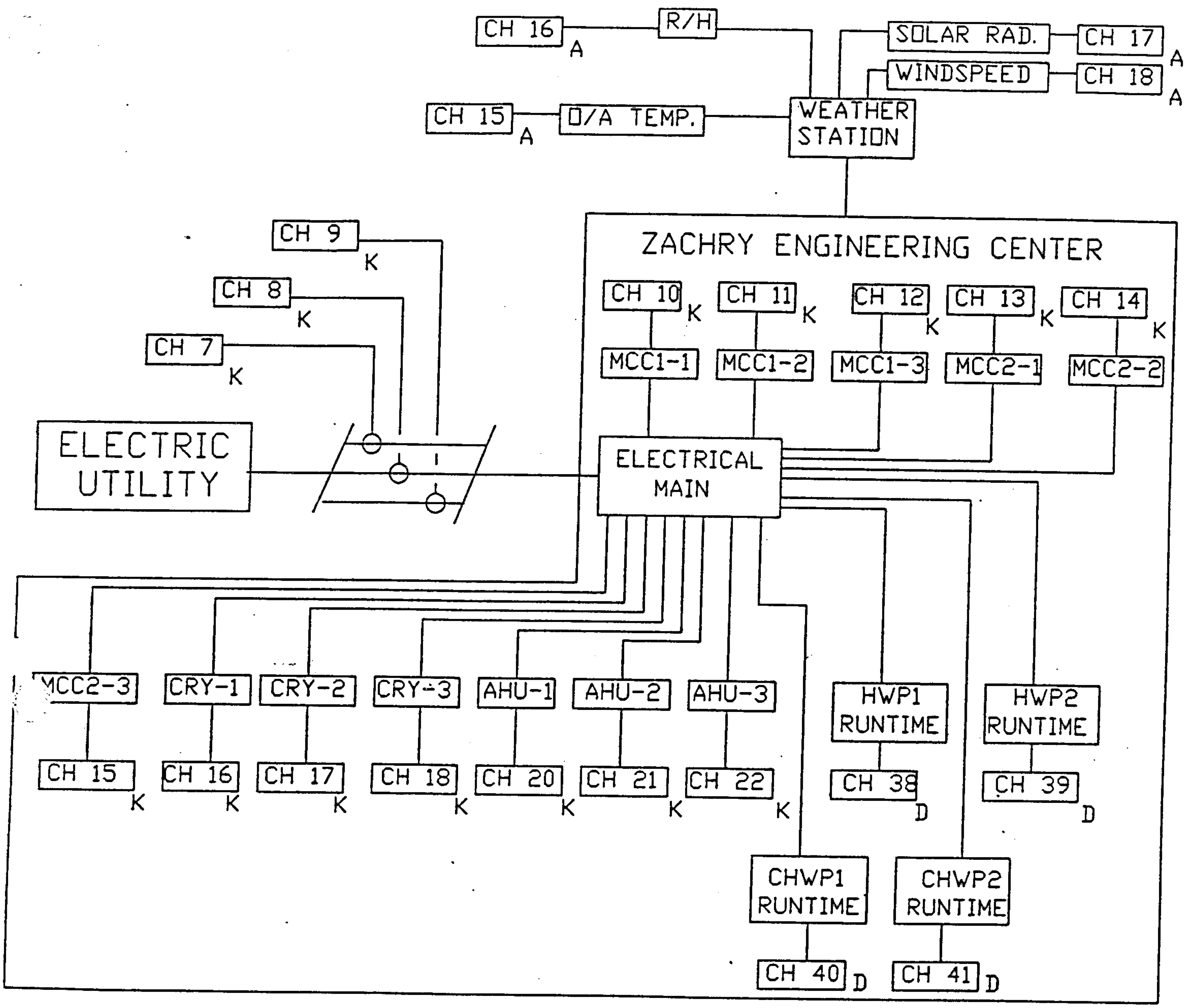
## ZACHRY ENGINEERING CENTER




SOURCE: Keith Boles
ESL, MECH. ENGG DEPT
ADDRESS, PHONE TEXAS A&M UNIV
845-1508
DATE: 05/25/91 BY: N.B.

# KWH MONITORING DIAGRAM

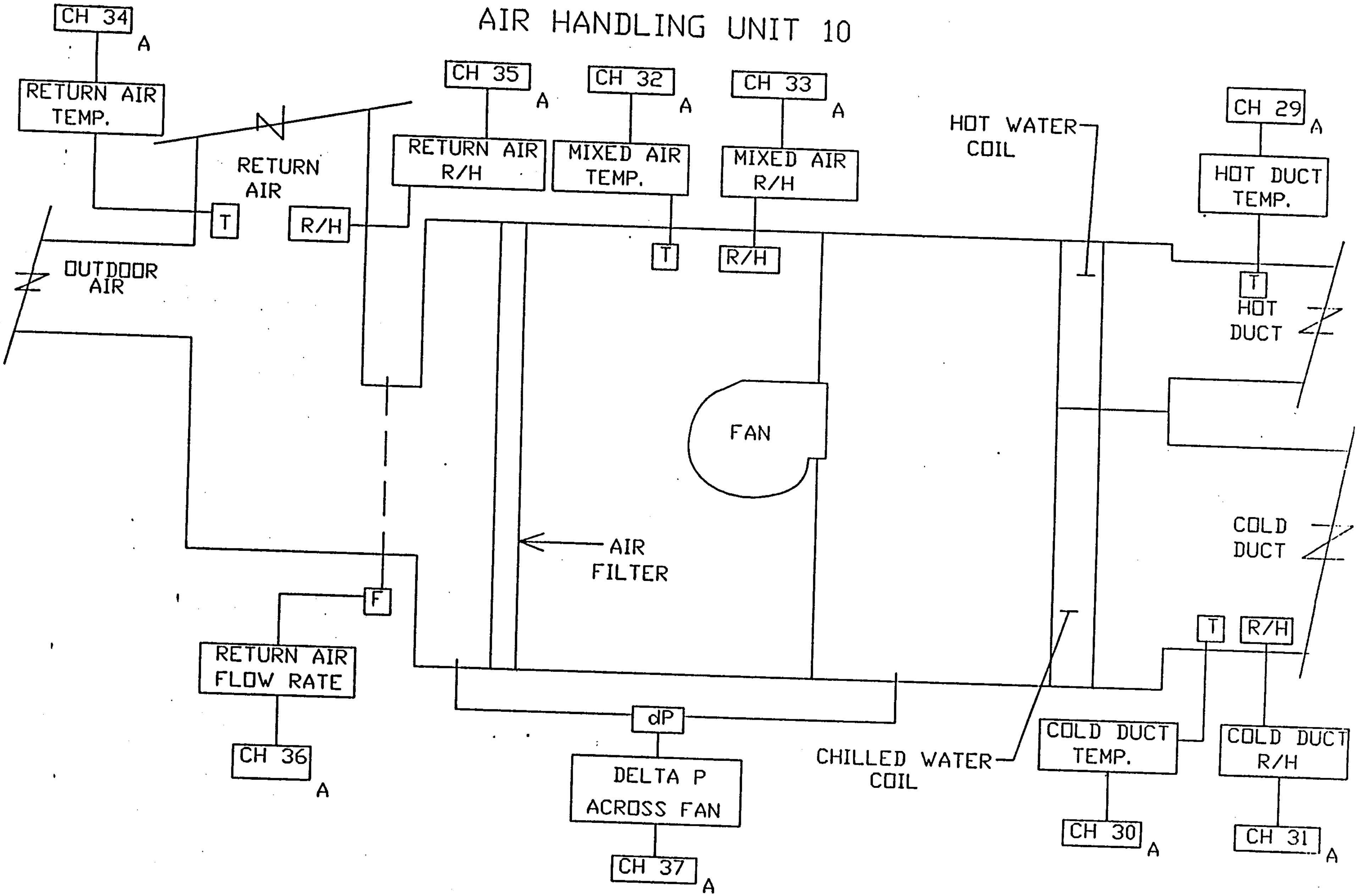
## ZACHRY ENGINEERING CENTER



# THERMAL MONITORING DIAGRAM B

## ZACHRY ENGINEERING CENTER

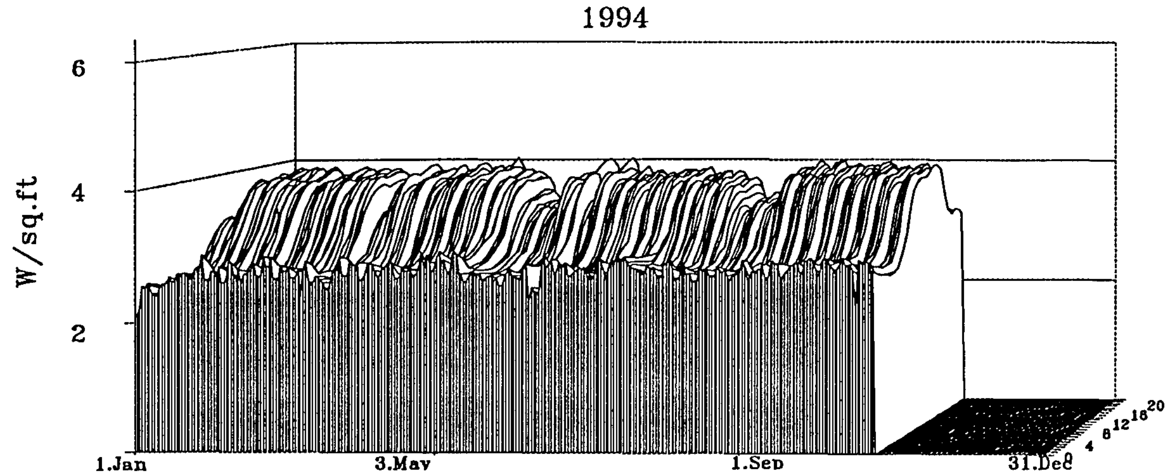
## AIR HANDLING UNIT 10

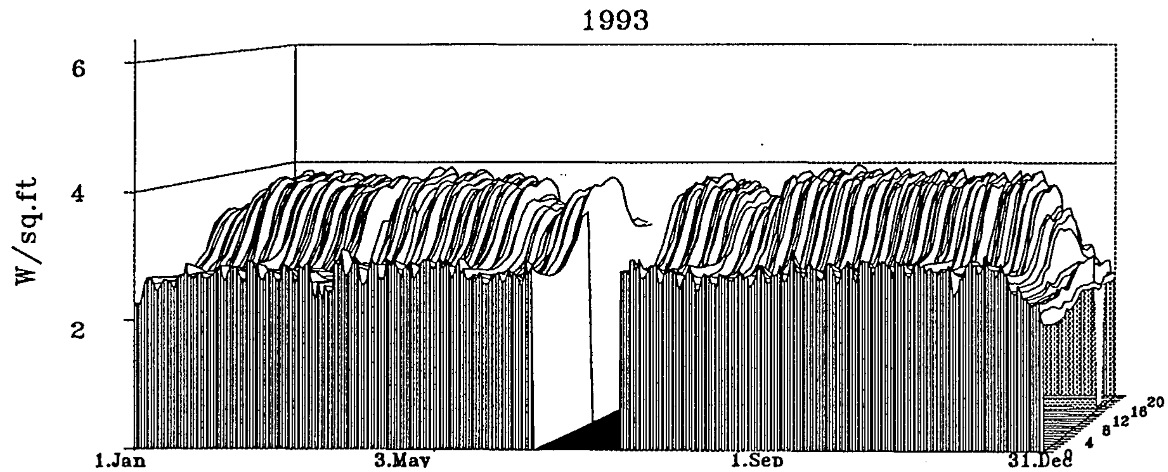


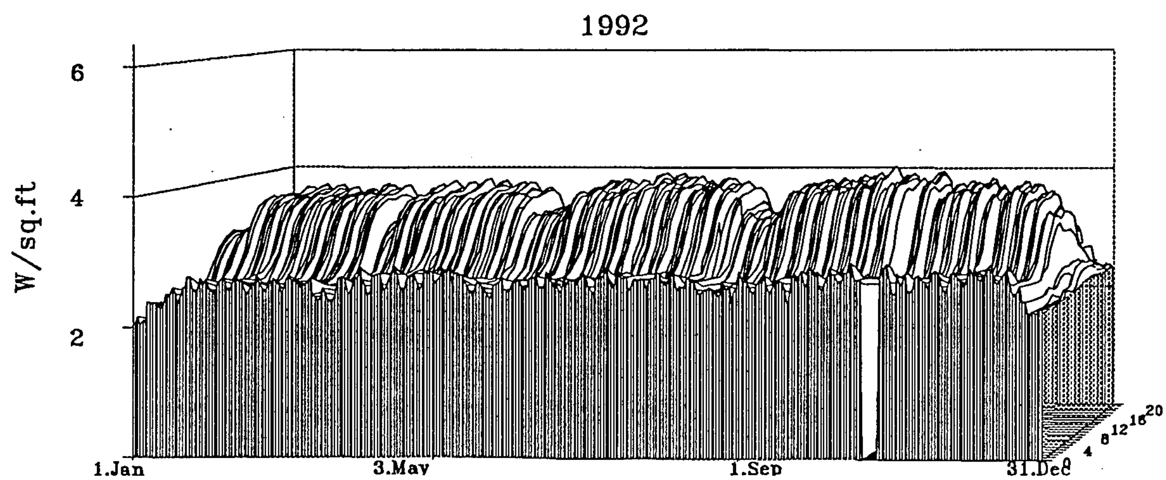
# Tab D-3

## 3-D Surface Plots

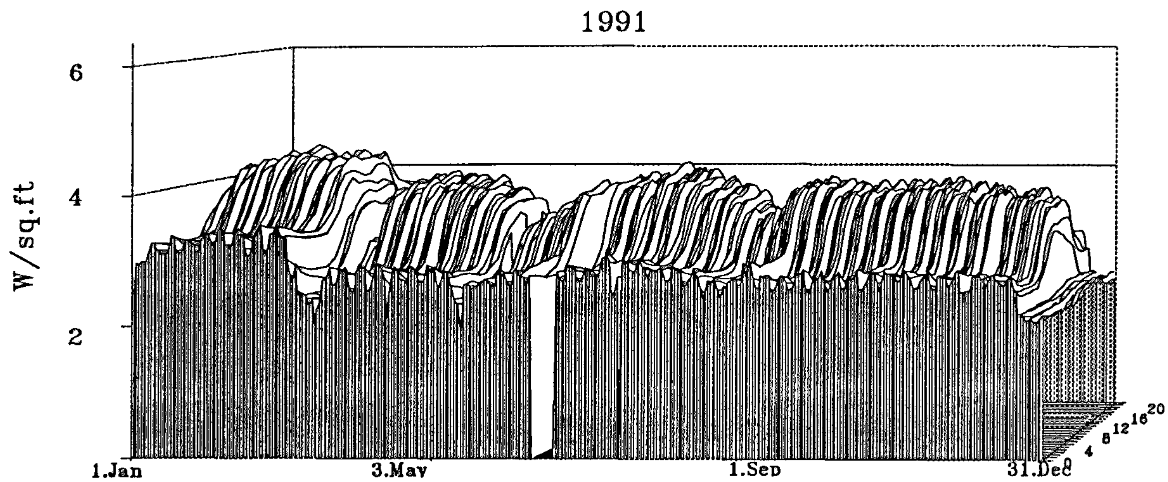
# Zachry Engineering Center (ZEC)
# W.B. Electric as W/sq.ft.

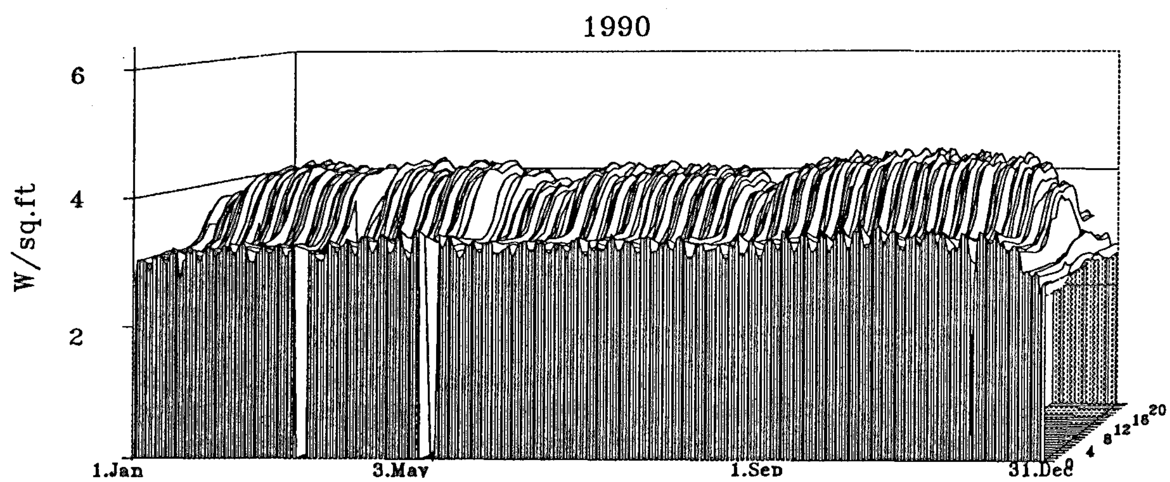


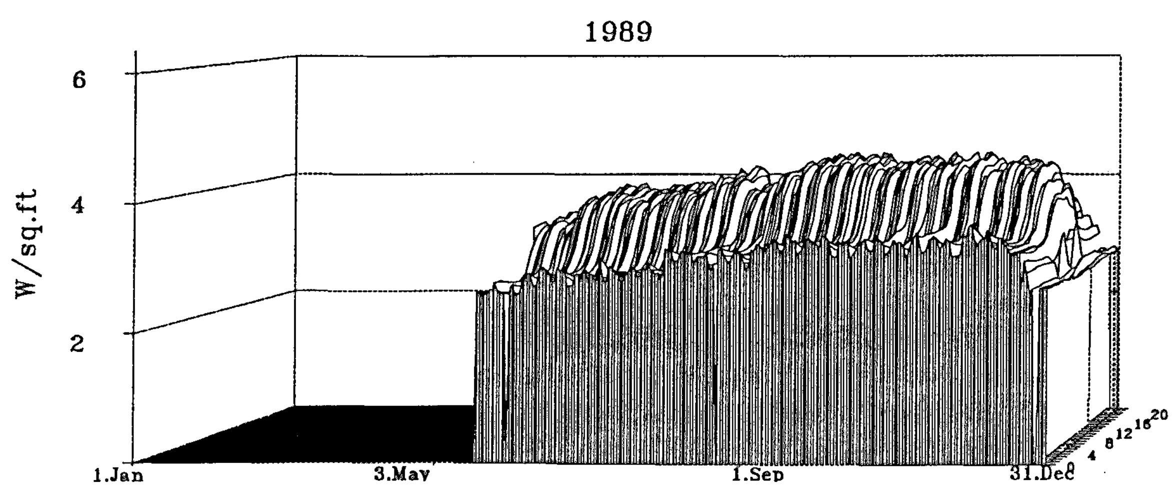



# Zachry Engineering Center (ZEC)
# W.B. Electric as W/sq.ft.

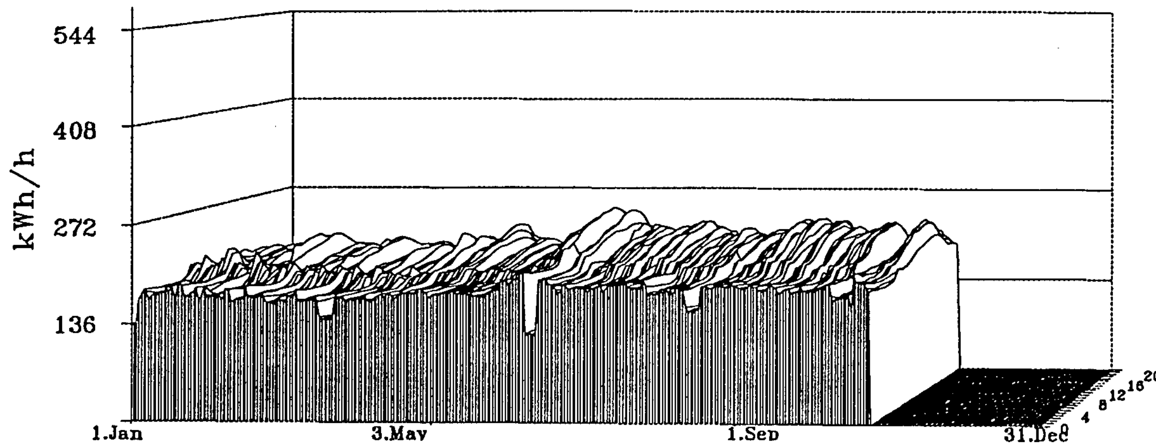


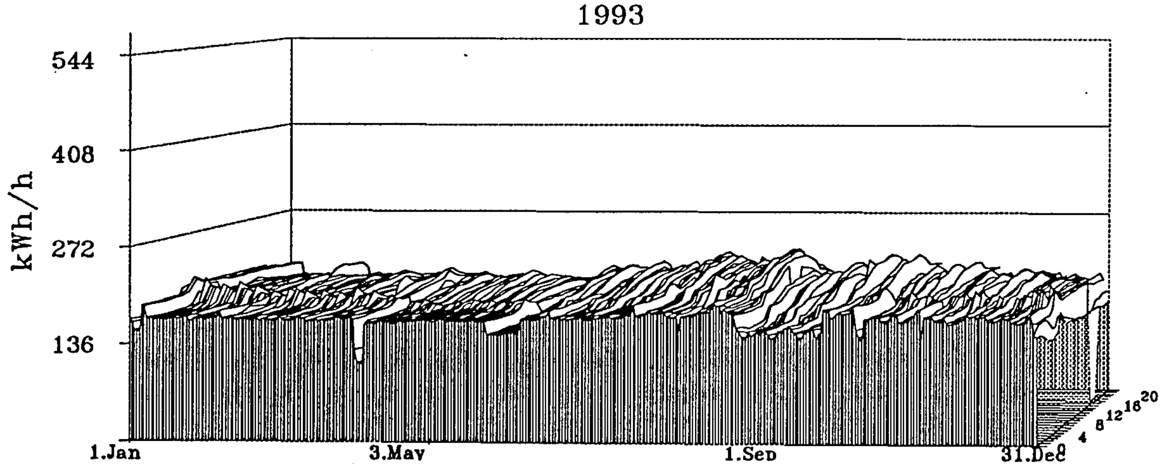



# Zachry Engineering Center (ZEC)
# Motor Control Cen. (kWh/h)

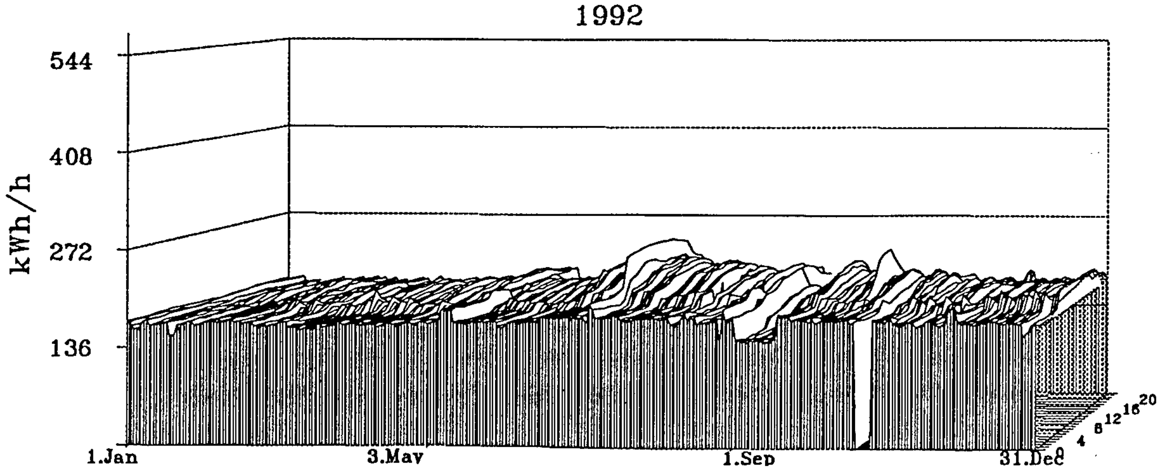
1994



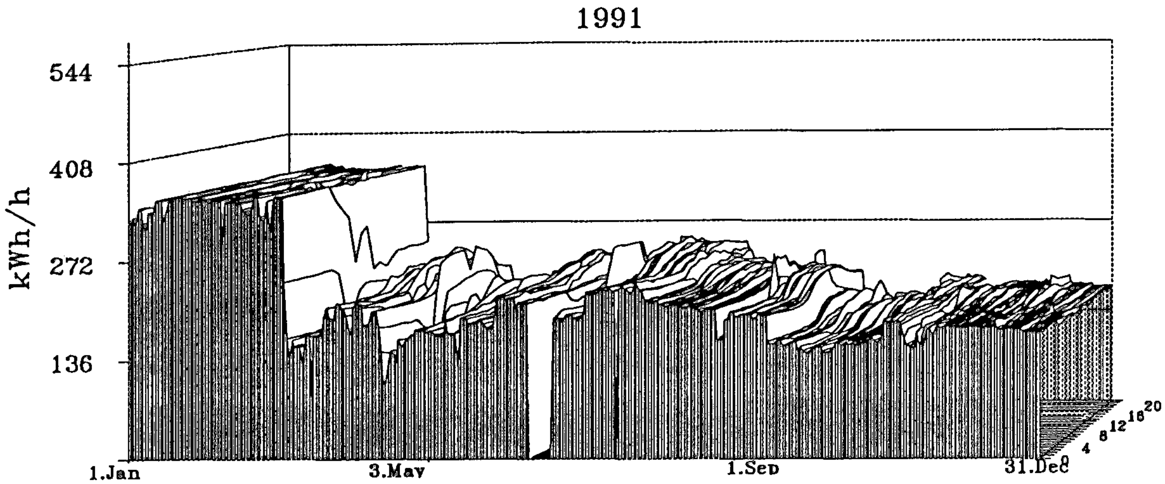

1993

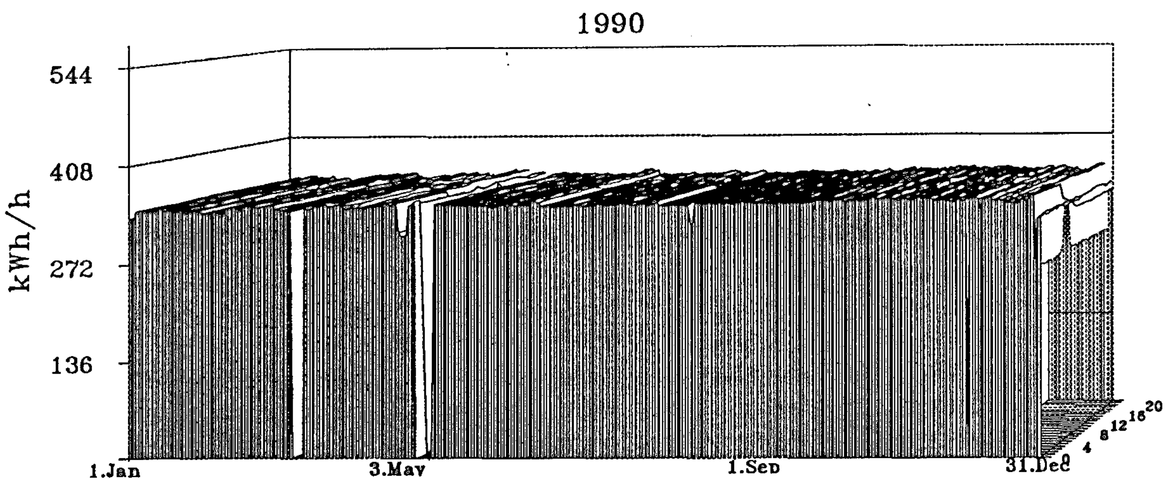


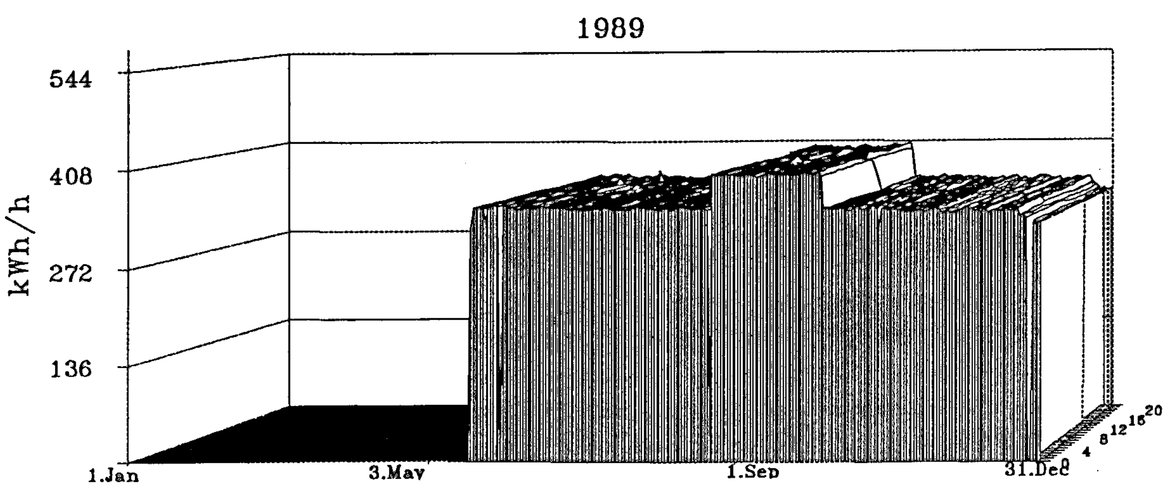

1992



## Zachry Engineering Center (ZEC)
## Motor Control Cen. (kWh/h)

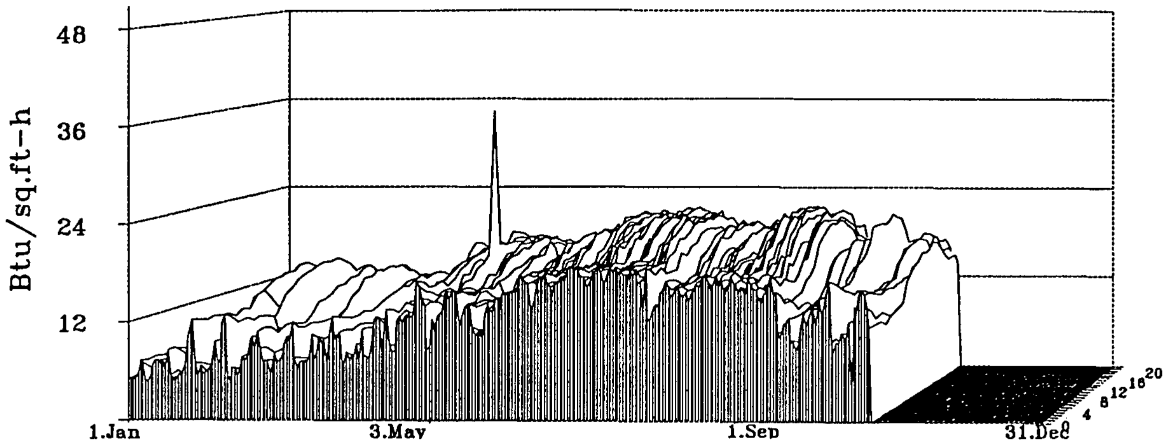


# Zachry Engineering Center (ZEC)
# W.B. CHW as Btu/sq.ft.-h

1994

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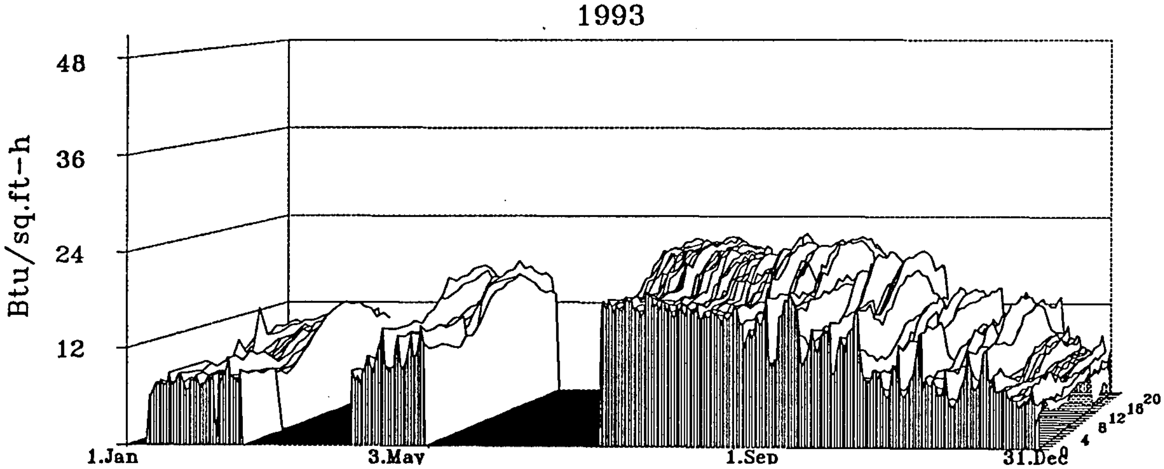
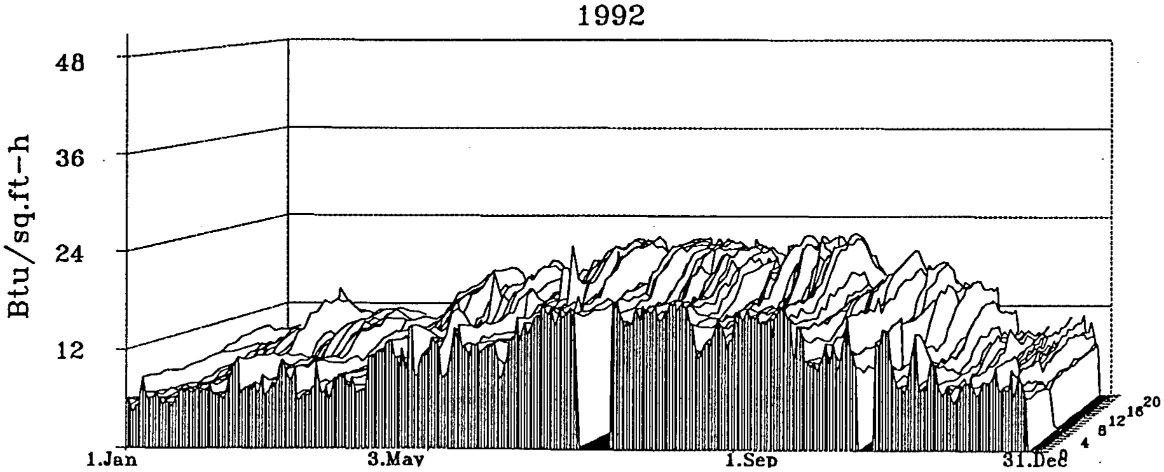
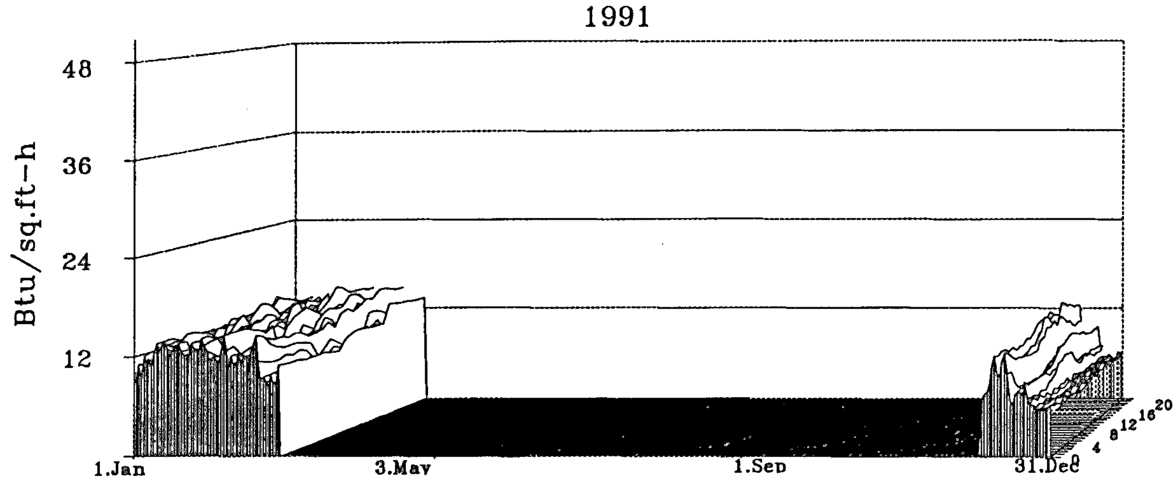
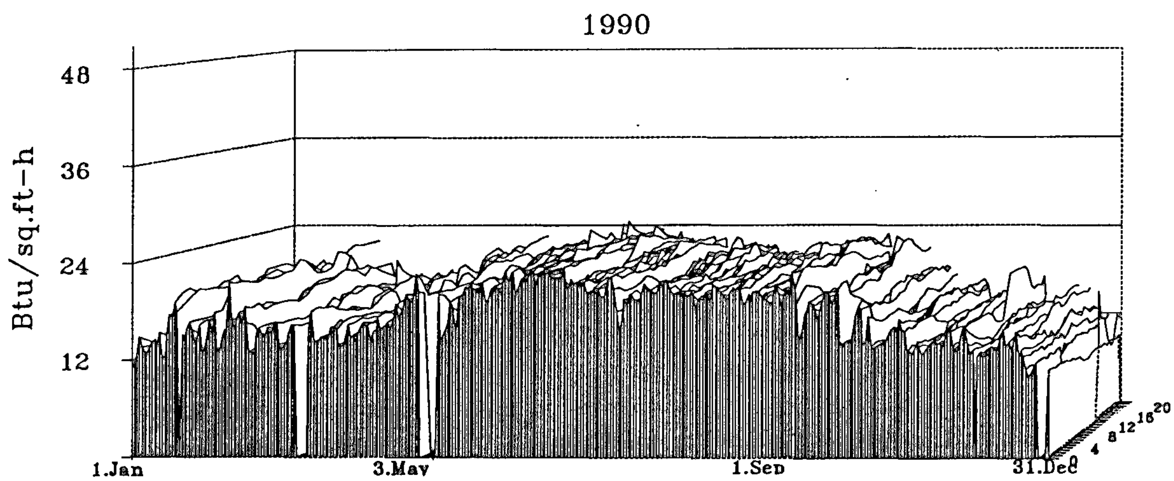


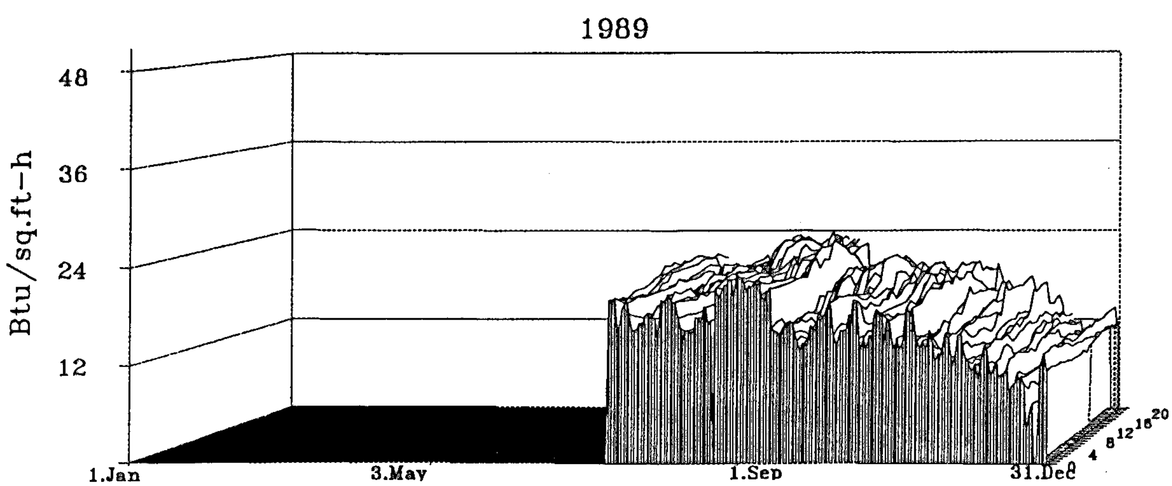

1992



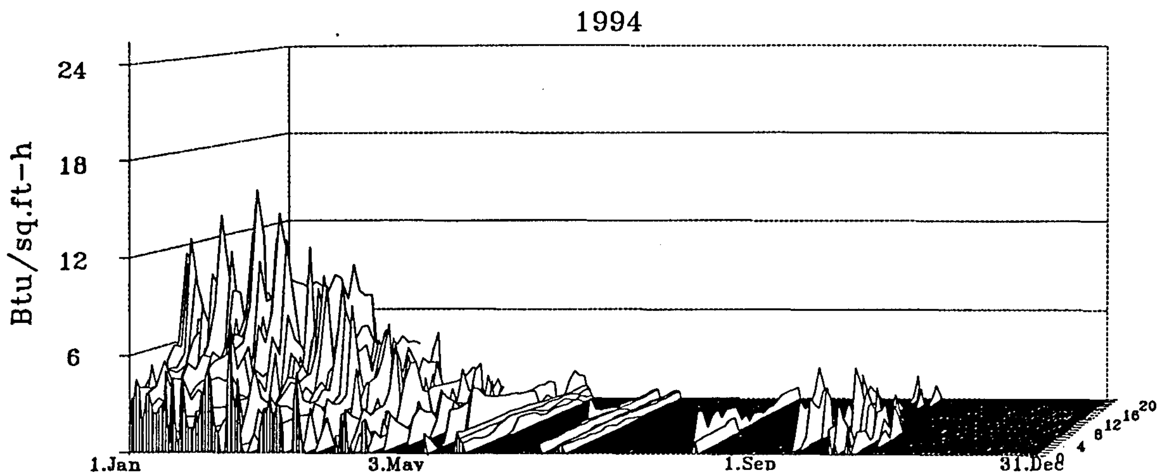
# Zachry Engineering Center (ZEC)
# W.B. CHW as Btu/sq.ft.-h

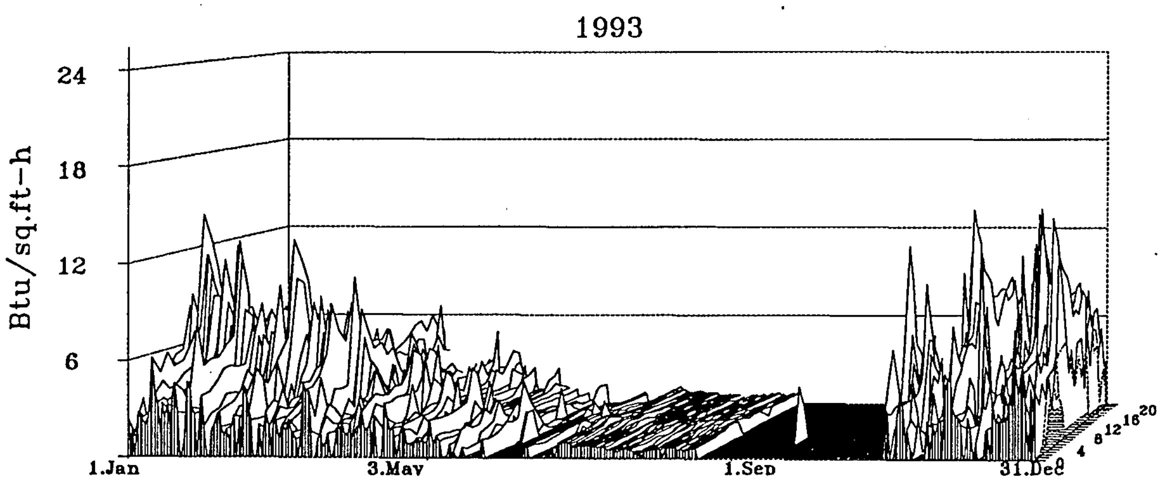


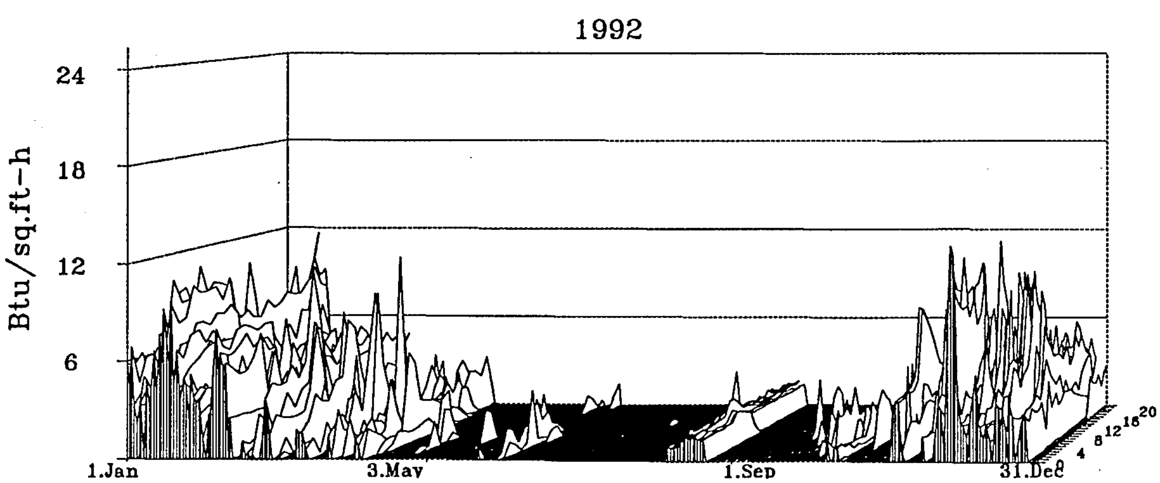



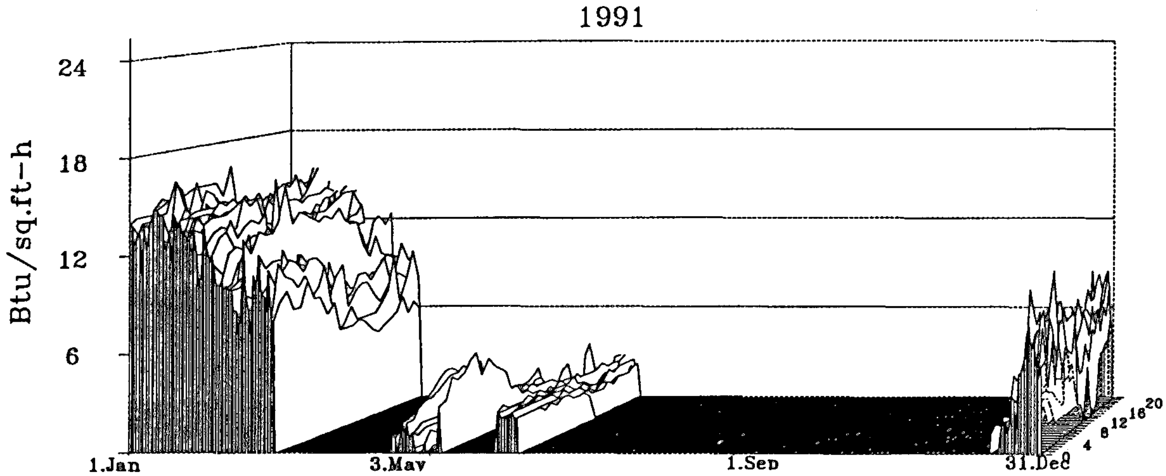
# Zachry Engineering Center (ZEC)
# W.B. HW as Btu/sq.ft.-h

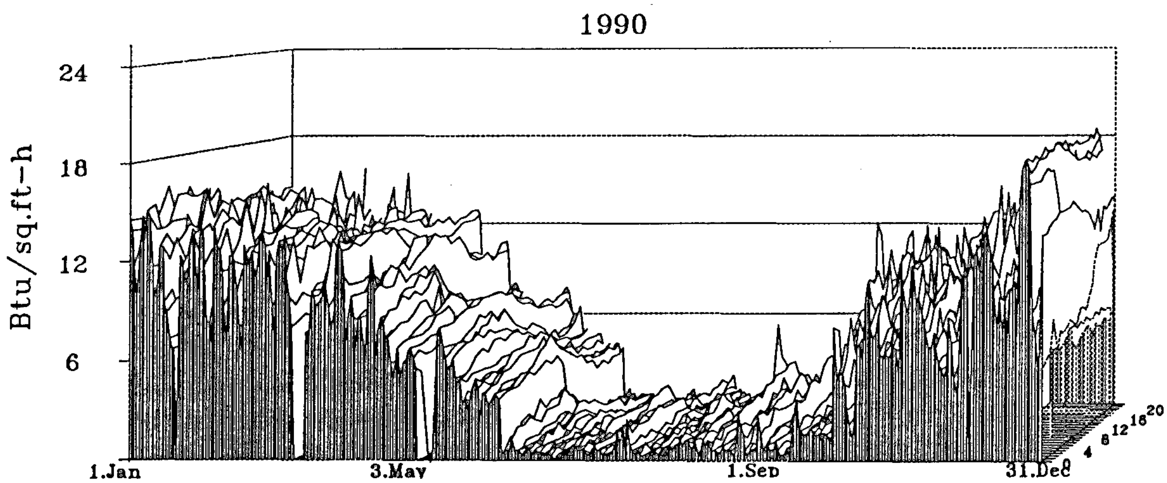


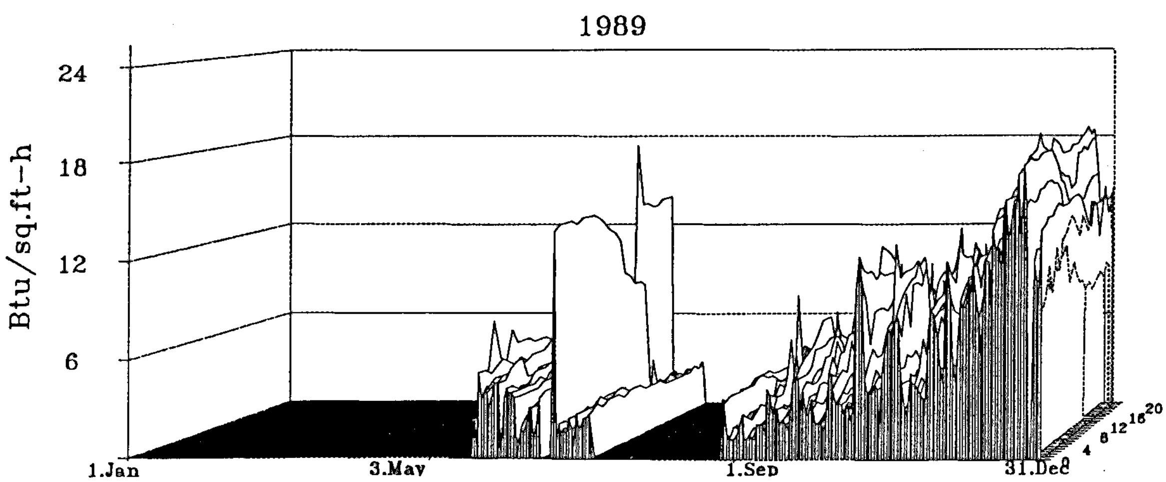



# Zachry Engineering Center (ZEC)
# W.B. HW as Btu/sq.ft.-h



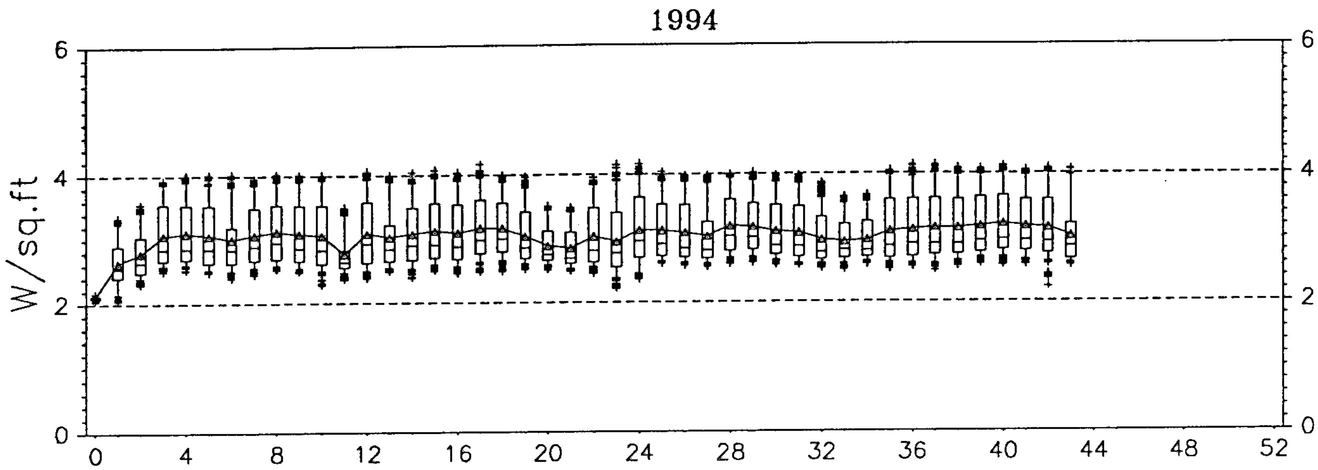



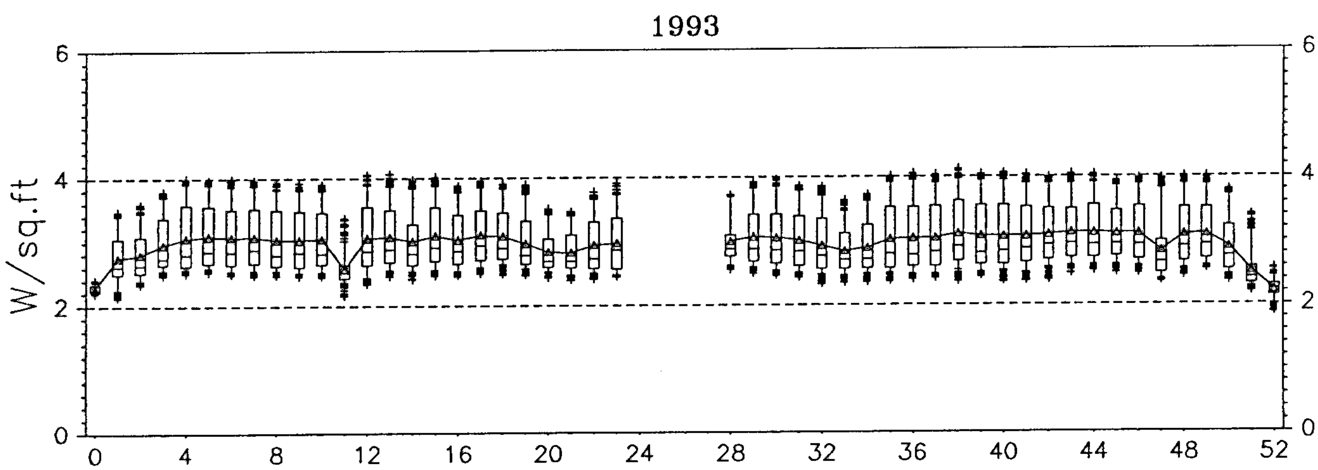



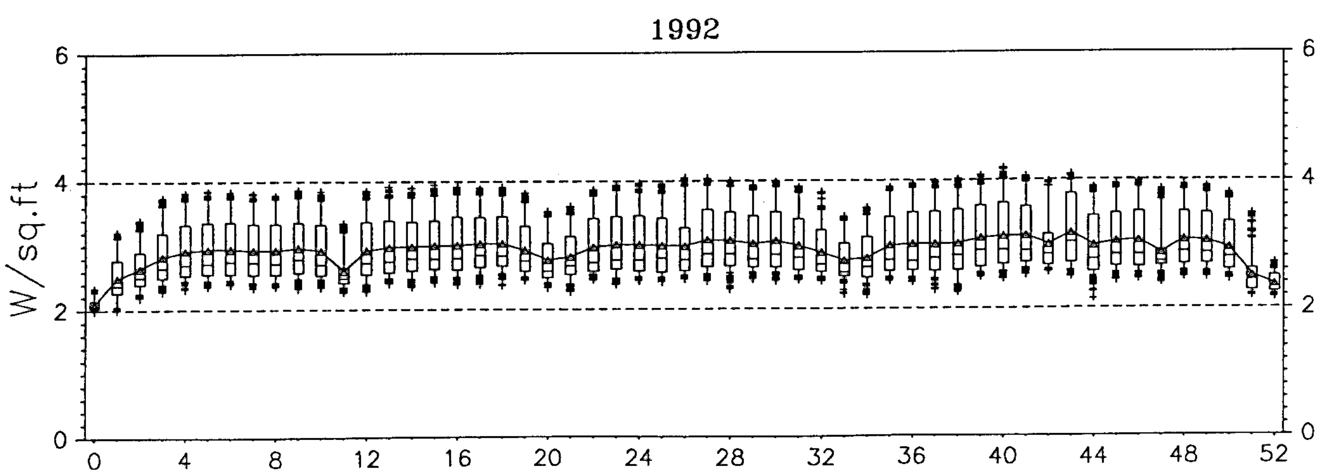
## Tab D-4

## Weekly Box Whisker Mean Plots

# Zachry Engineering Center (ZEC)
# W.B. Electric as W/sq.ft.

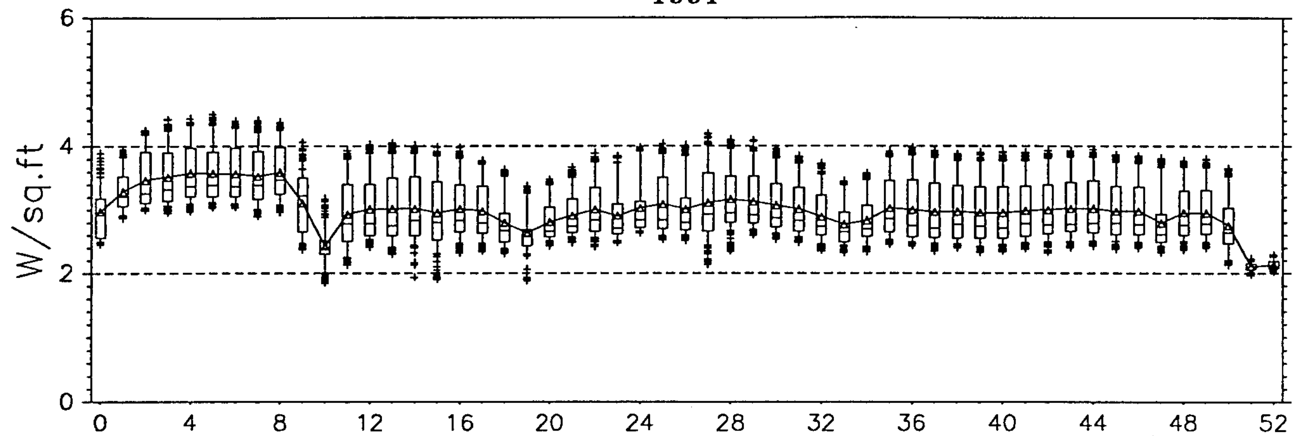


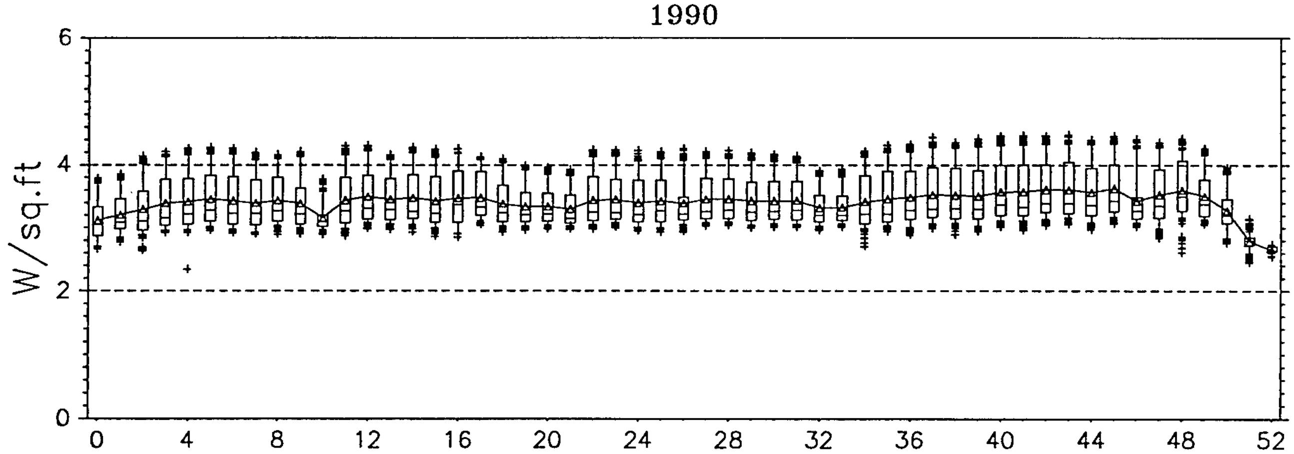



# Zachry Engineering Center (ZEC)
# W.B. Electric as W/sq.ft.

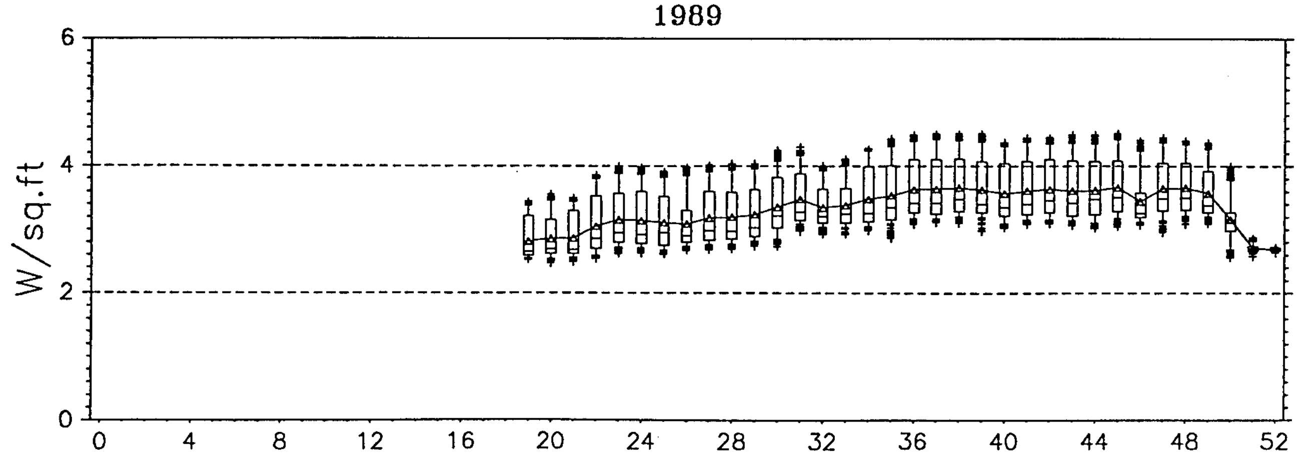
1991



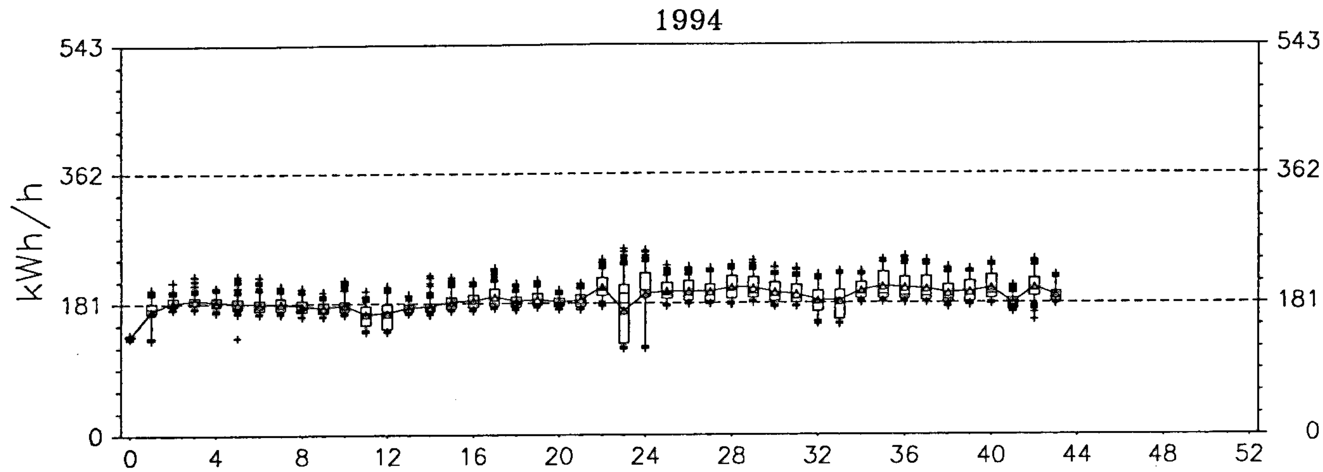

1990

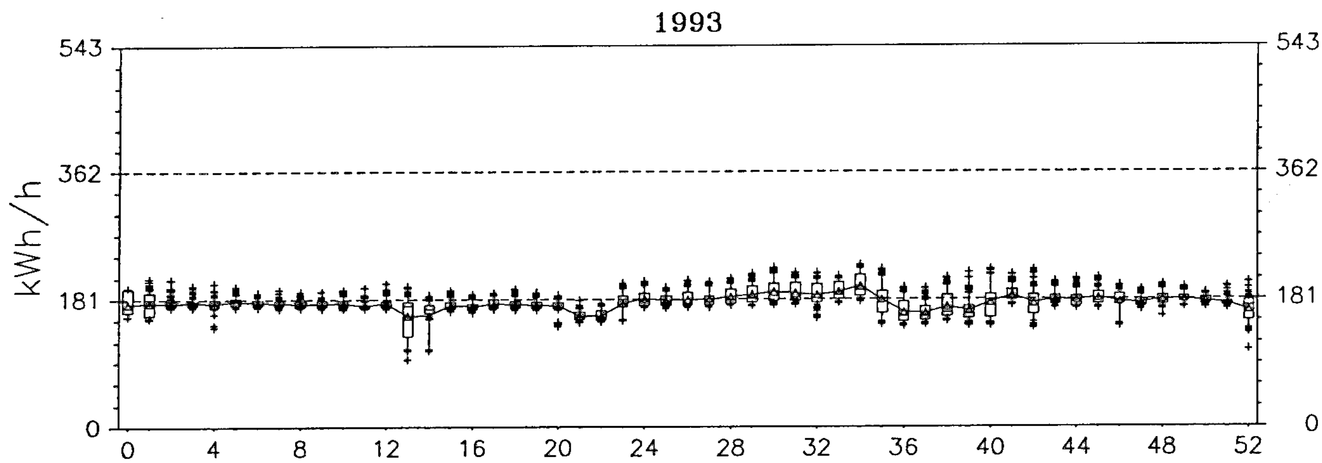


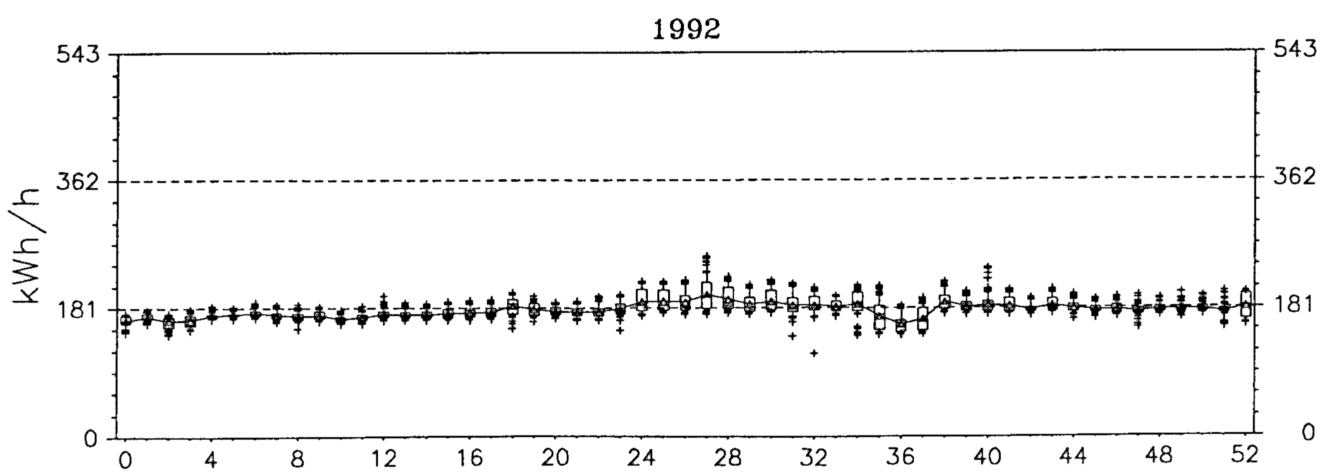

1989



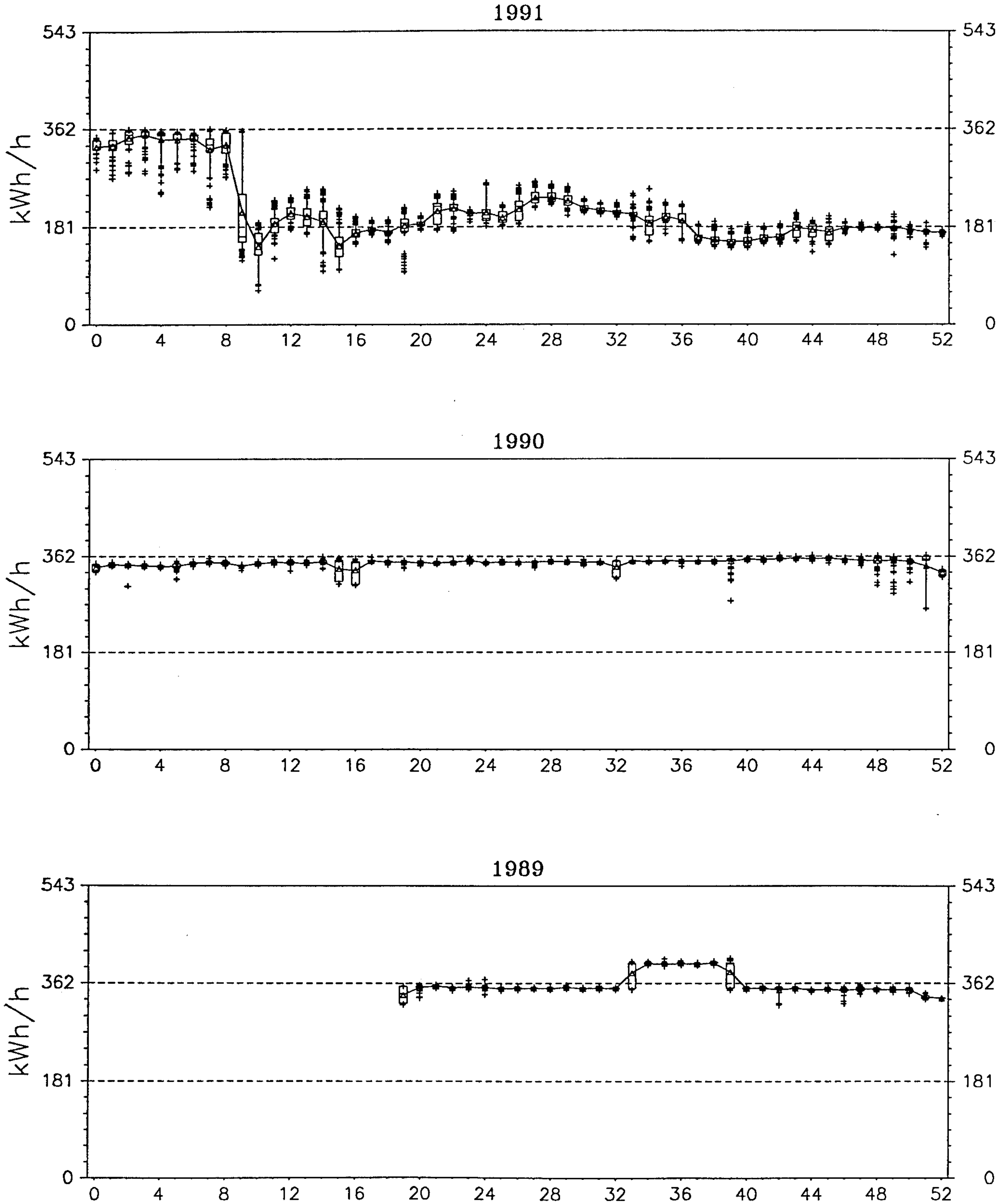
# Zachry Engineering Center (ZEC)
# Motor Control Cen. (kWh/h)



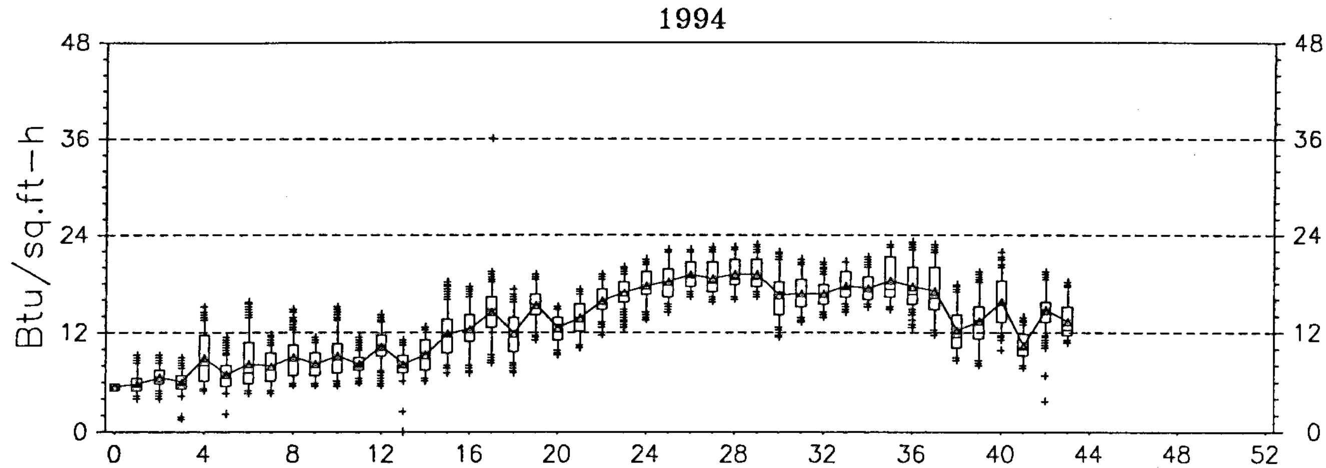



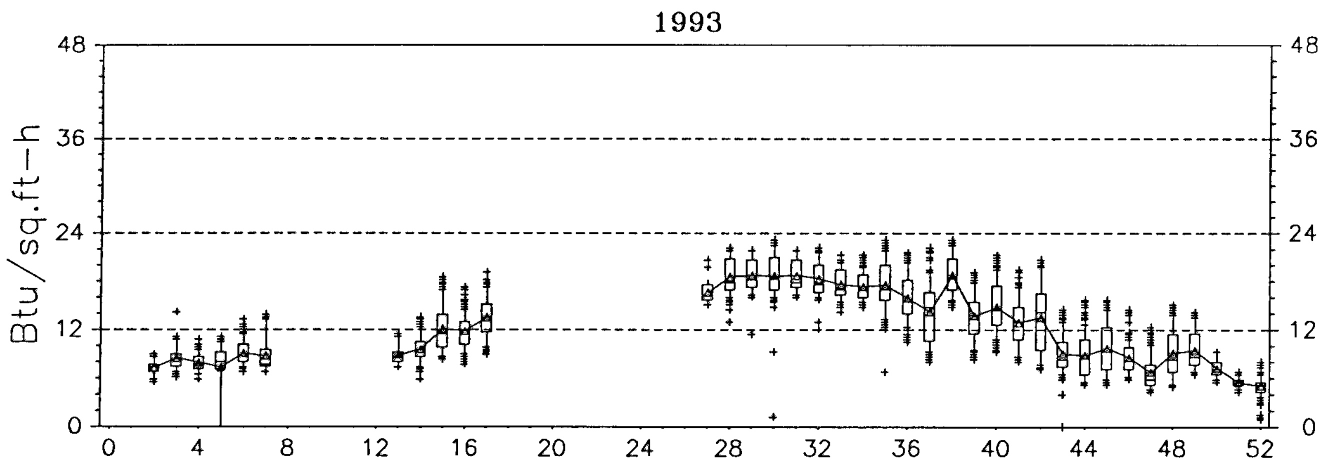



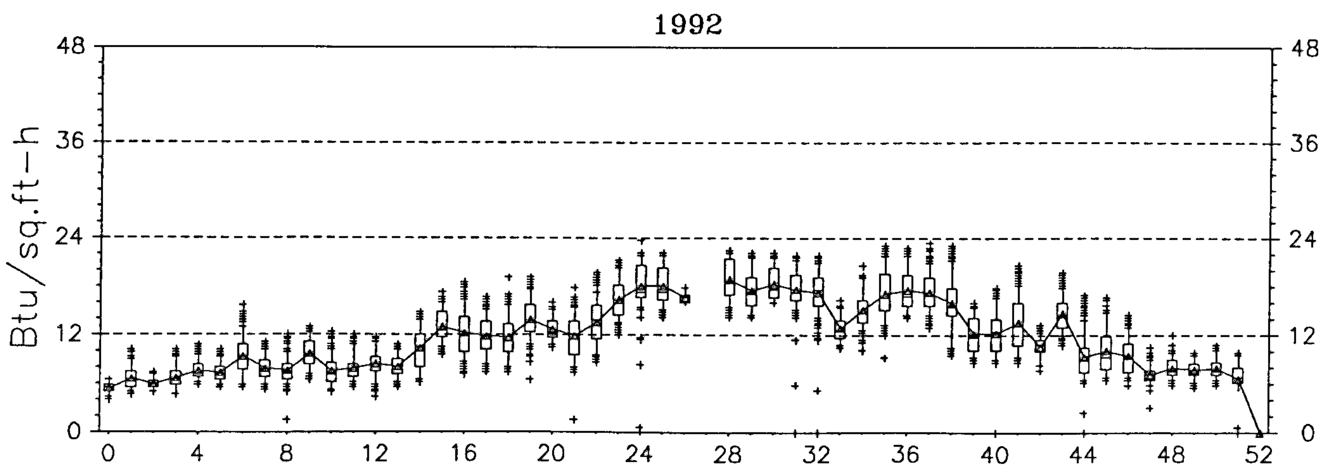
# Zachry Engineering Center (ZEC)
# Motor Control Cen. (kWh/h)



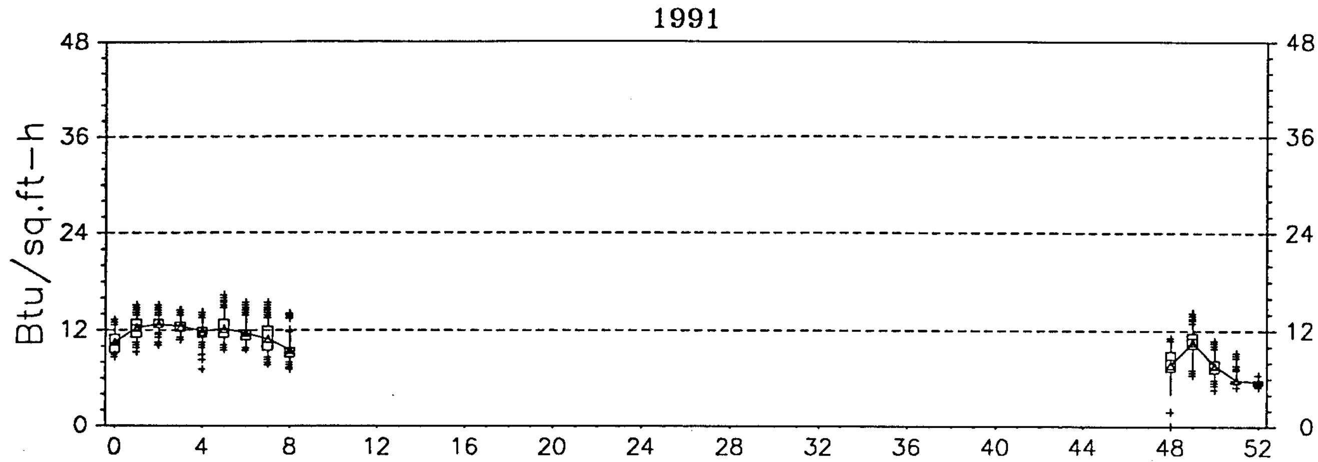
# Zachry Engineering Center (ZEC)
# W.B. CHW as Btu/sq.ft.-h

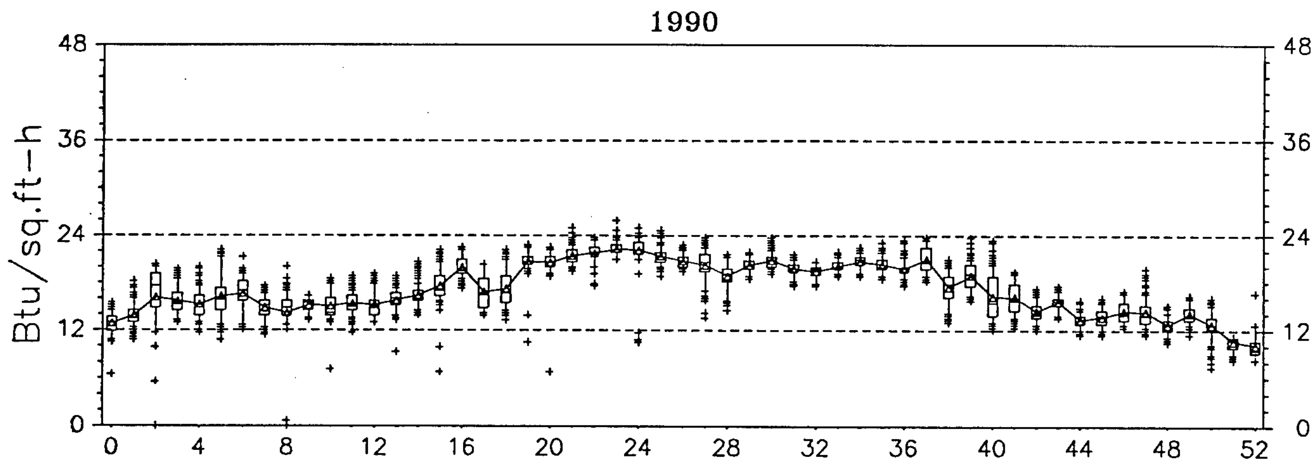


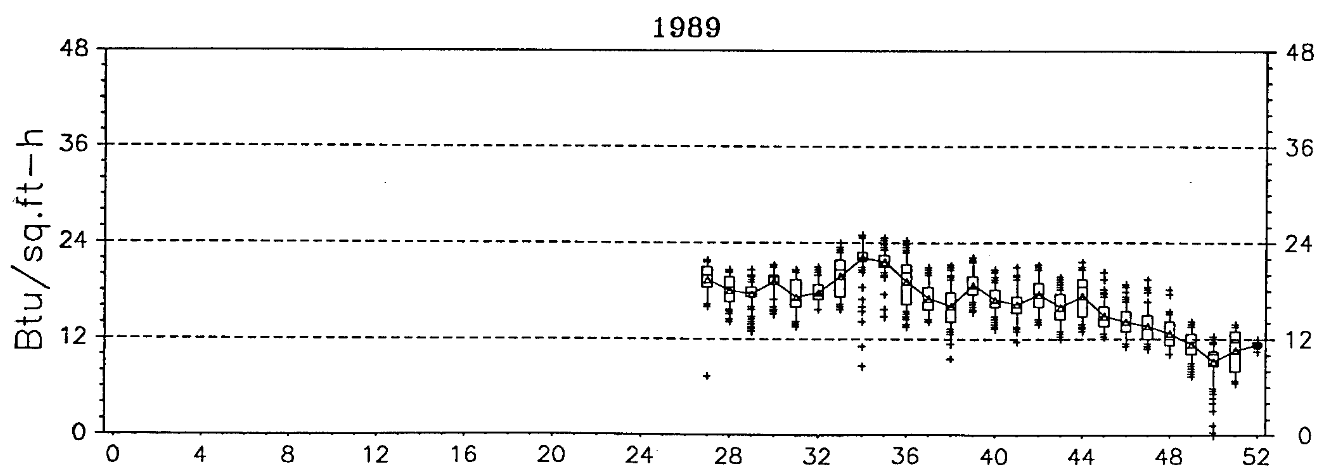



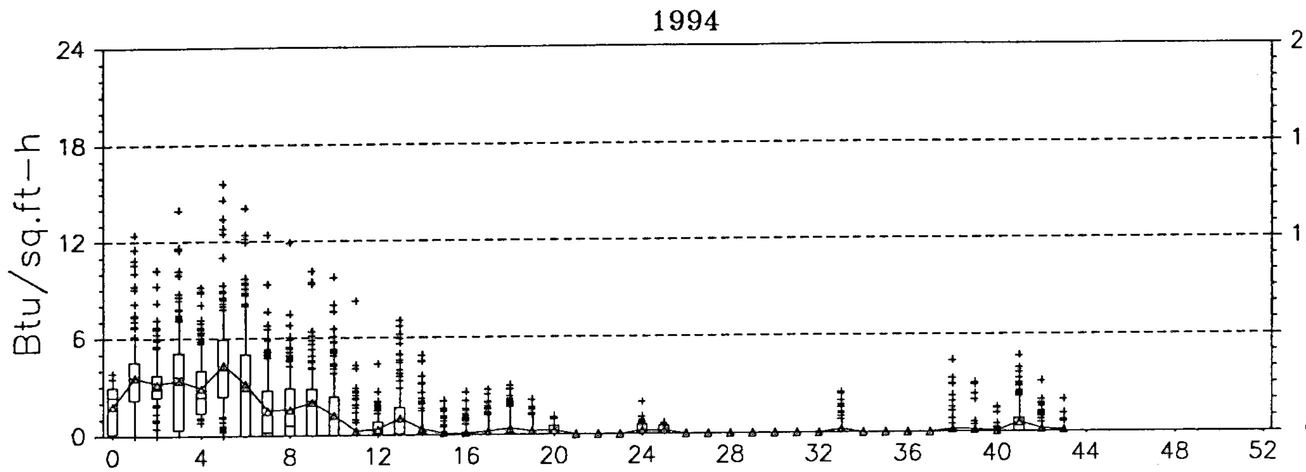
# Zachry Engineering Center (ZEC)
# W.B. CHW as Btu/sq.ft.-h

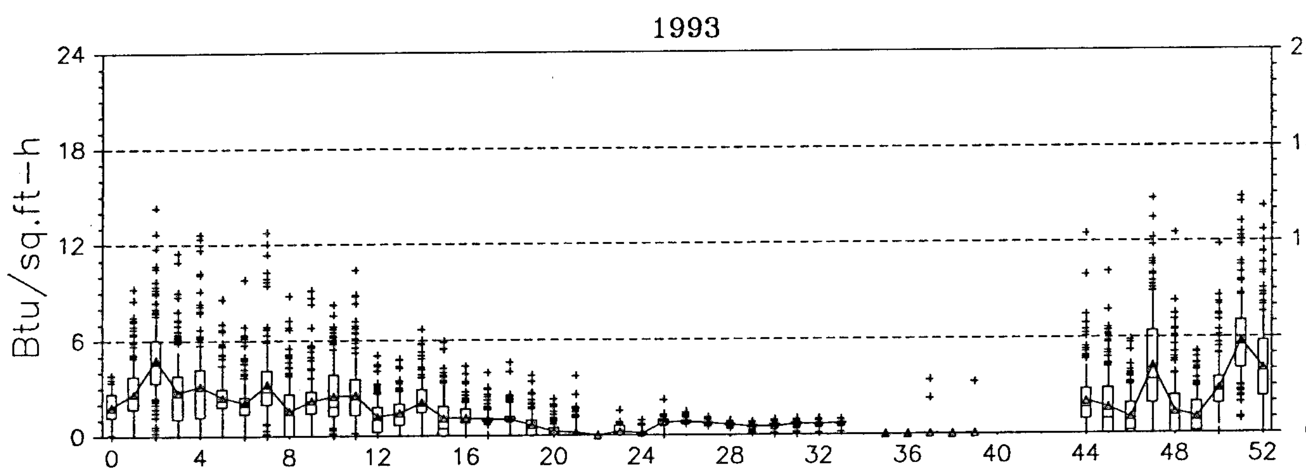


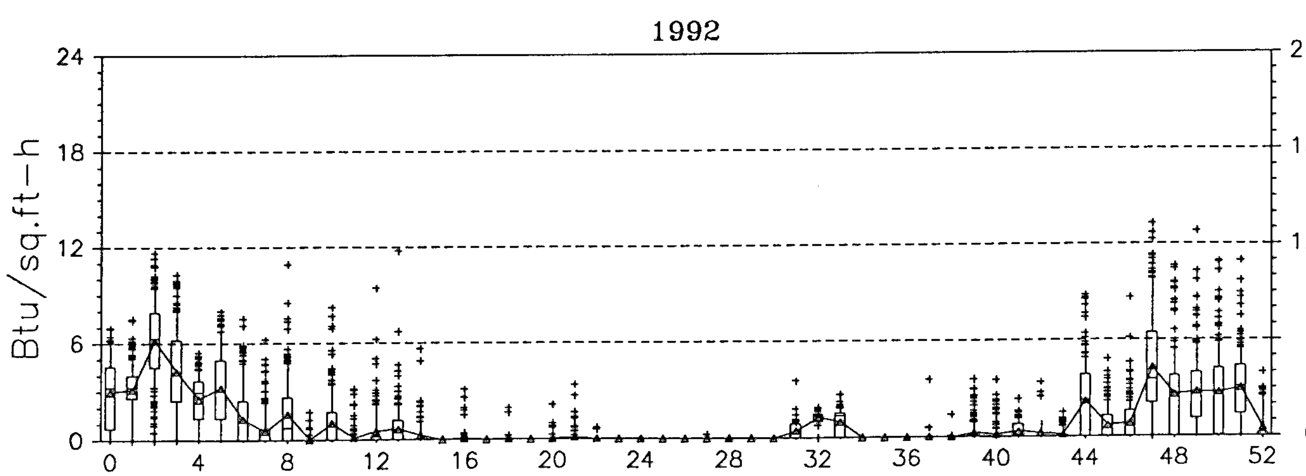



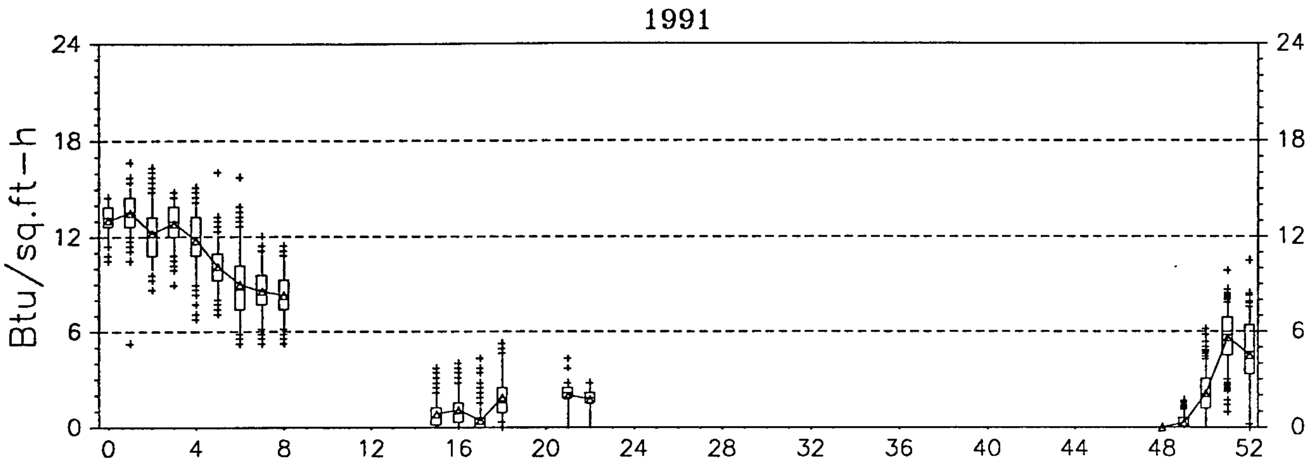
# Zachry Engineering Center (ZEC)
# W.B. HW as Btu/sq.ft.-h

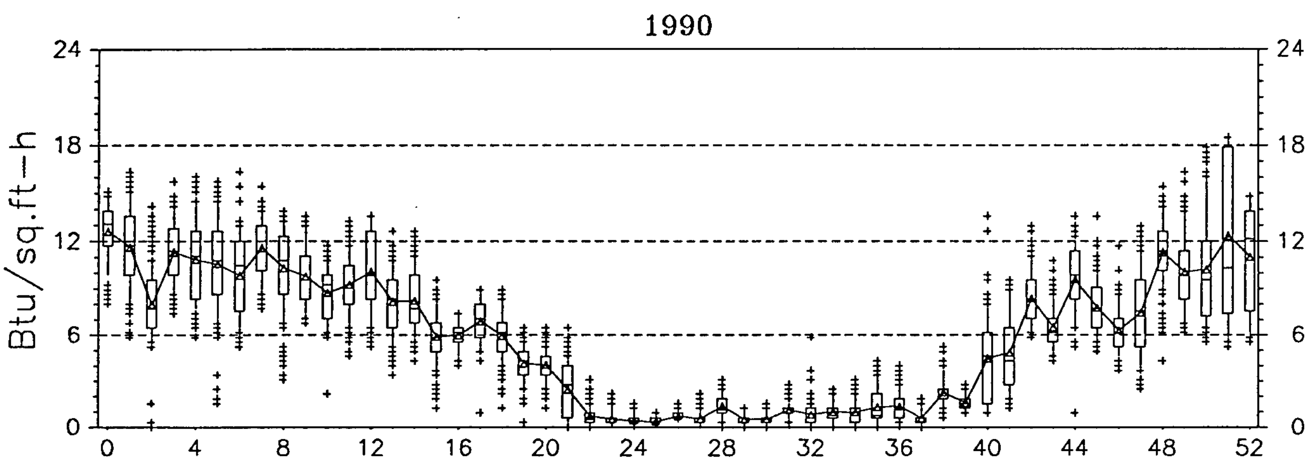


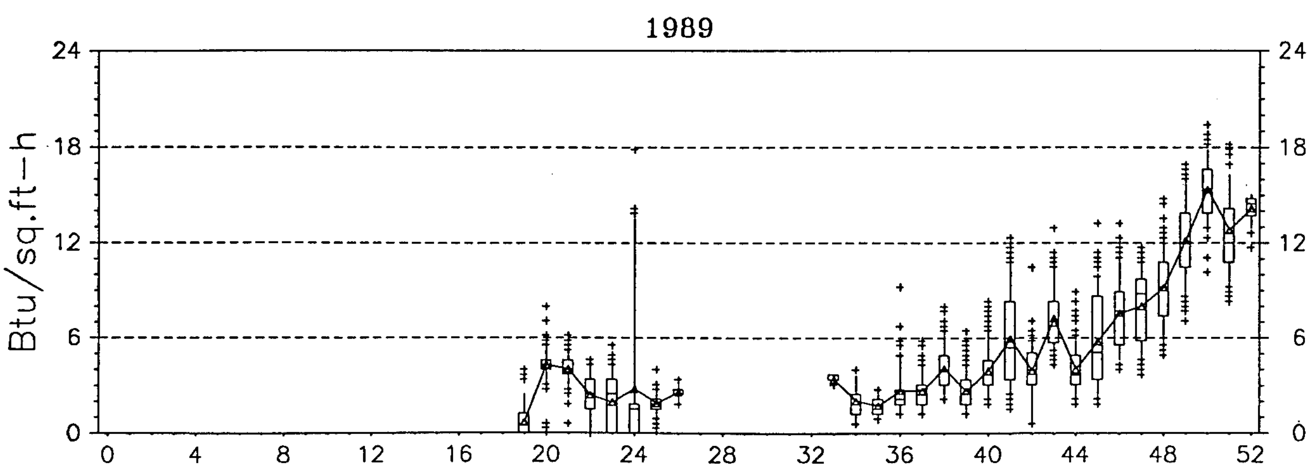



# Zachry Engineering Center (ZEC)
# W.B. HW as Btu/sq.ft.-h



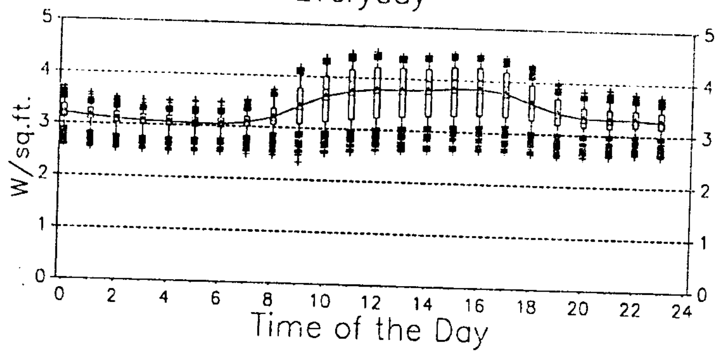
## Tab D-5

## Pre/Post, Weekday/Weekend, 24 Hour BWM Plots

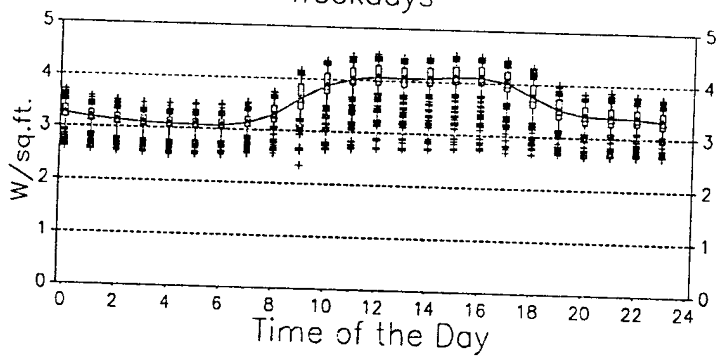
# Zachry Engineering Center (ZEC)
# W.B. Electric as W/sq.ft.

## Pre-Retrofit (05/31/1989 - 11/28/1990)

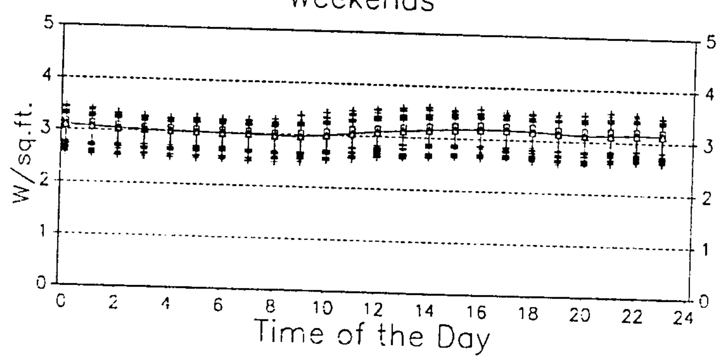
Everyday




Weekdays

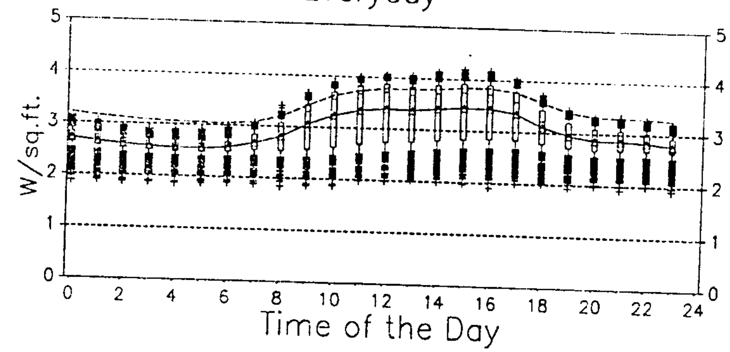



Weekends

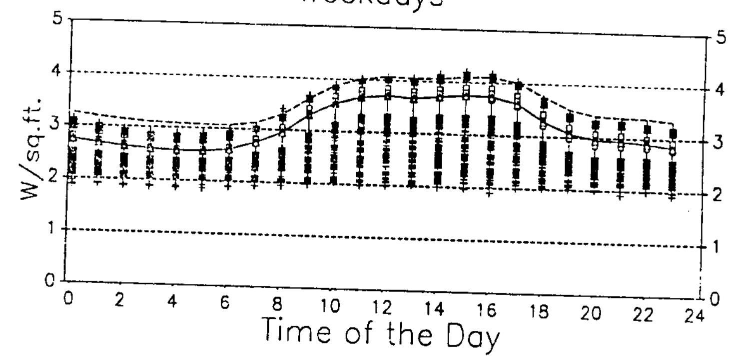



## Post-Retrofit (03/06/1991 - 12/31/1994)

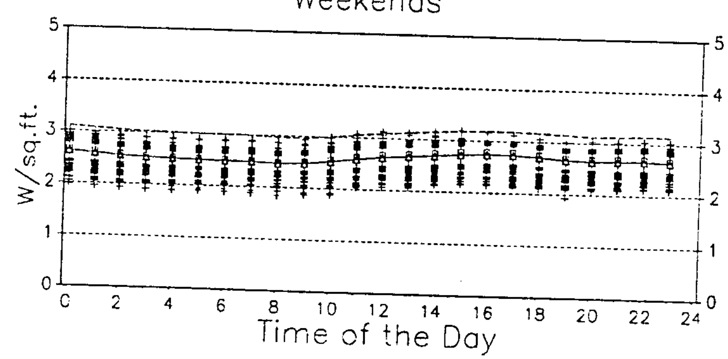
Everyday




Weekdays




Weekends



Tab D-6

Tab D-6

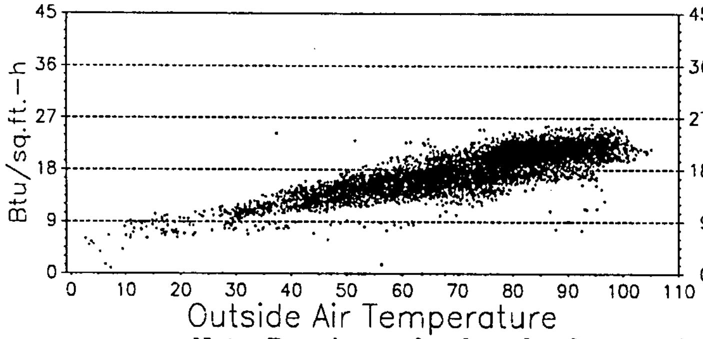
# Pre/Post, Weekday/Weekend, BWM Temperature Binned Plots

Pre/Post, Weekday/Weekend, BWM Temperature Binned Plots

# Zachry Engineering Center (ZEC)
# W.B. CHW as Btu/sq.ft.-h

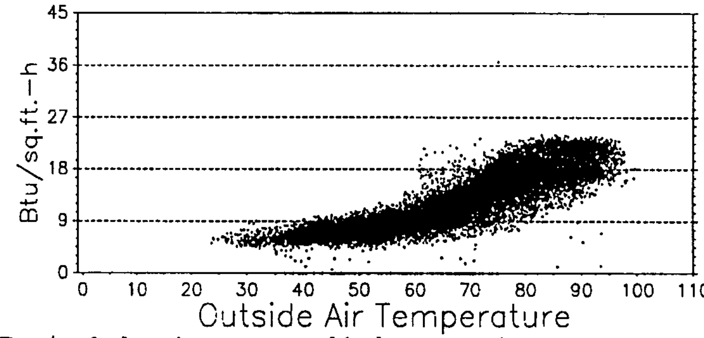
## Pre-Retrofit (05/31/1989 - 11/28/1990)

Everyday



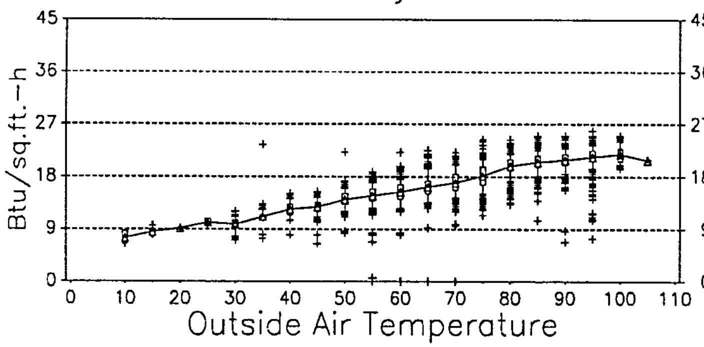

## Post-Retrofit (03/06/1991 - 12/31/1994)

Everyday

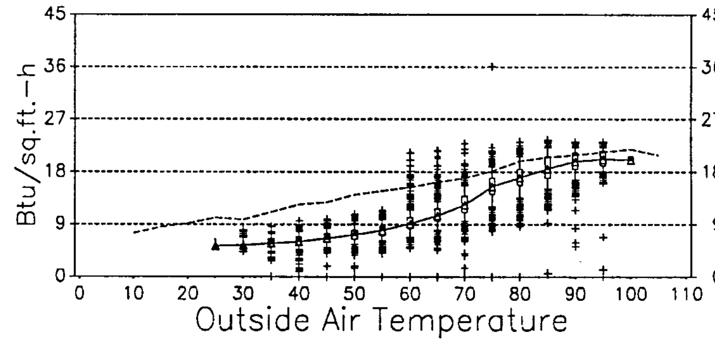



**Note: Data in graphs above has been vertically offset randomly up to 1 Btu/sq.ft.-h to improve graphical presentation.**

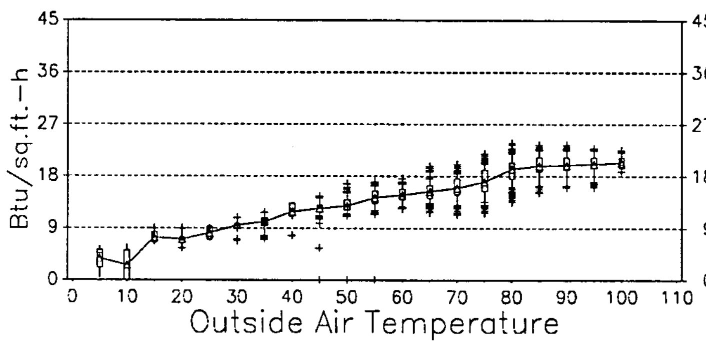
Weekdays



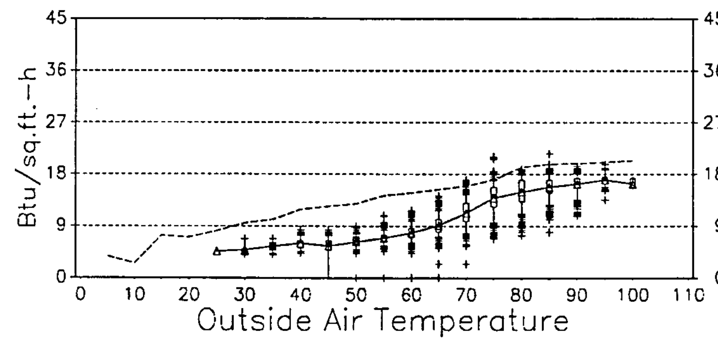

Weekdays




Weekends



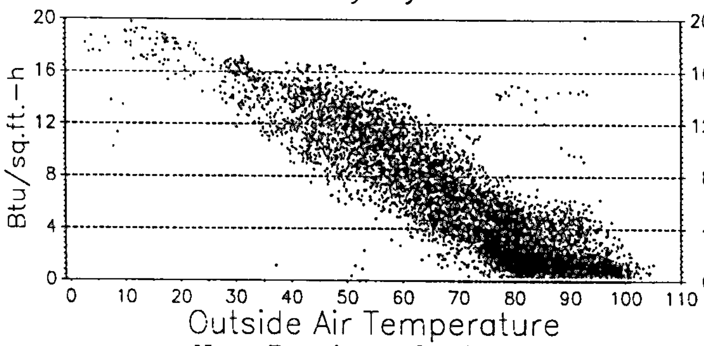

Weekends



# Zachry Engineering Center (ZEC)
# W.B. HW as Btu/sq.ft.-h

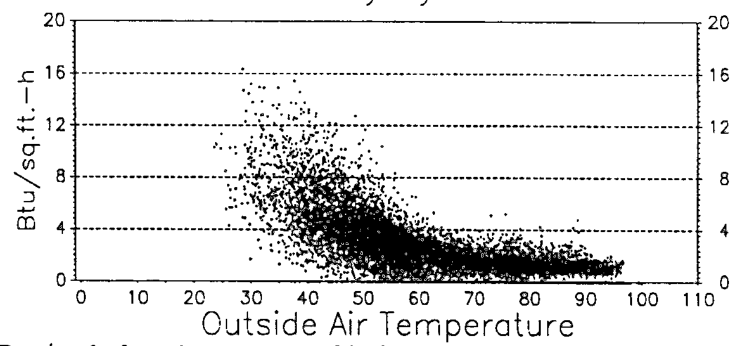
## Pre-Retrofit (05/31/1989 - 11/28/1990)

Everyday



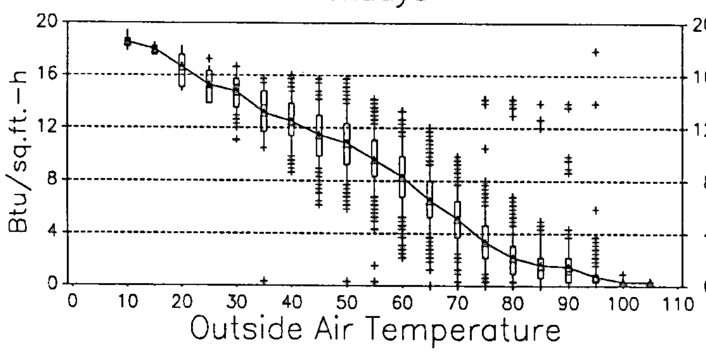

## Post-Retrofit (03/06/1991 - 12/31/1994)

Everyday

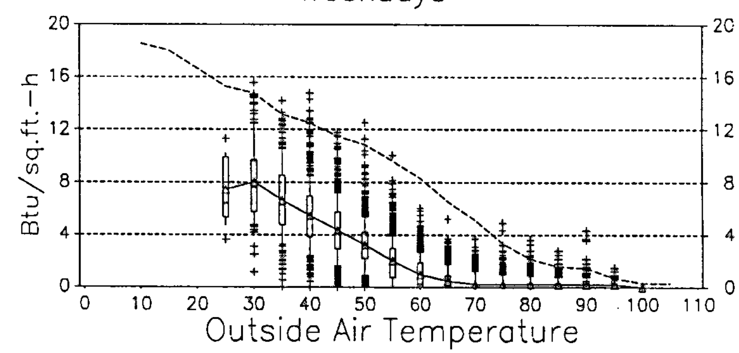



**Note: Data in graphs above has been vertically offset randomly up to 1 Btu/sq.ft.-h to improve graphical presentation.**

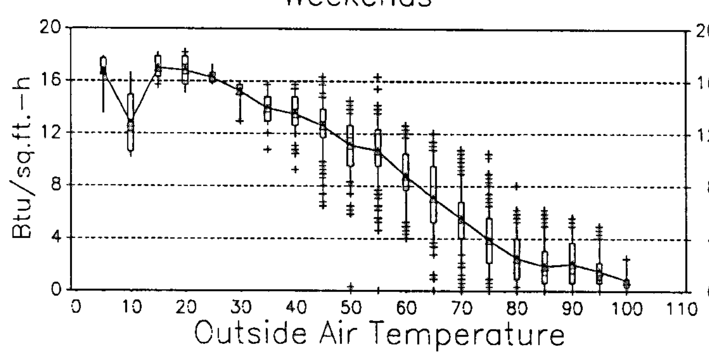
Weekdays



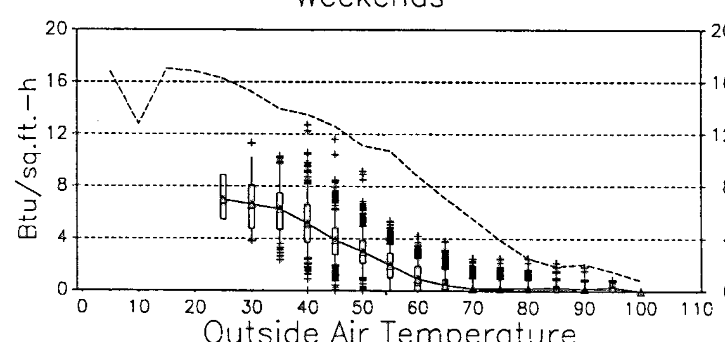

Weekdays




Weekends




Weekends

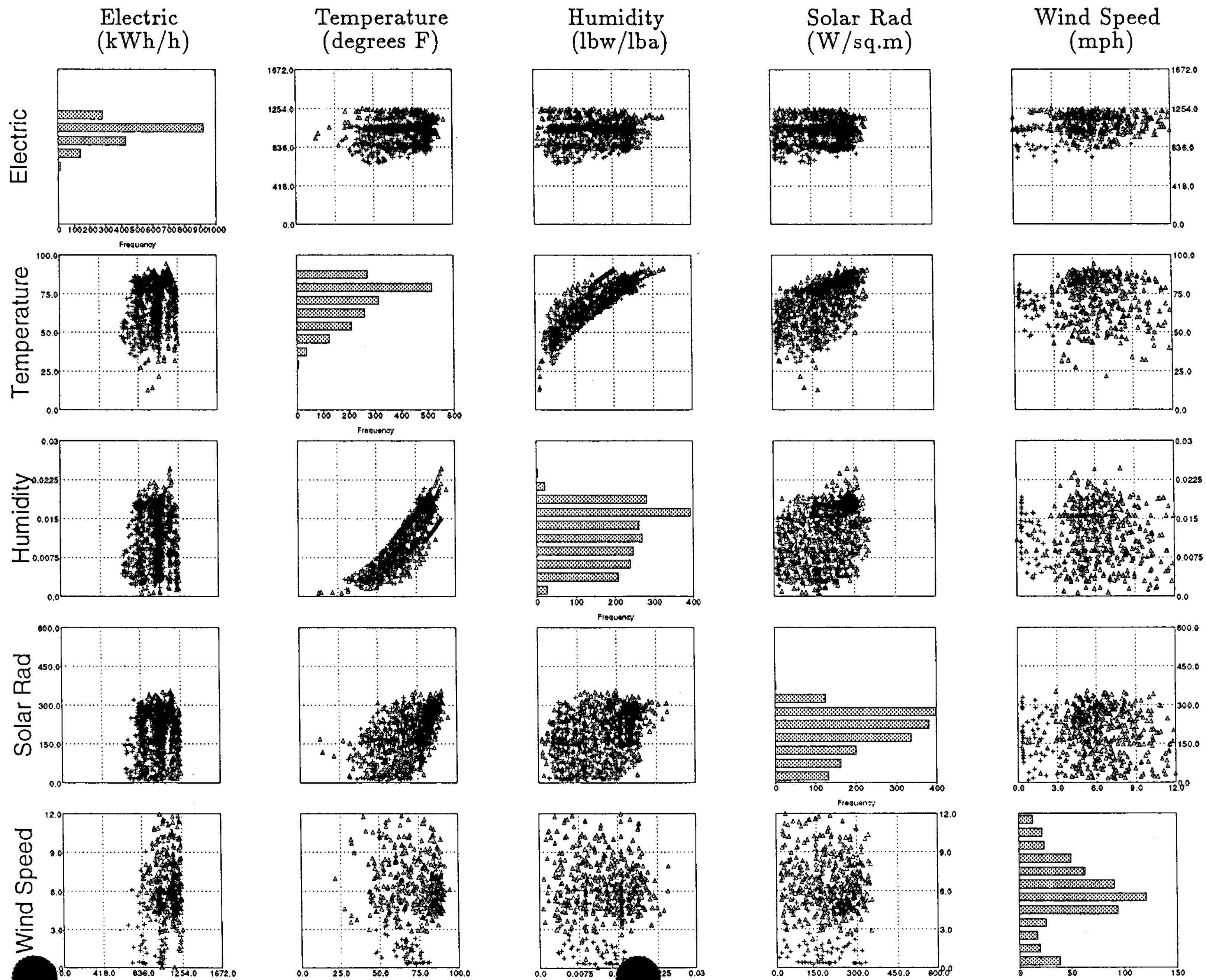


## Tab D-7

## Carpet Plots of Energy Use versus Ambient Conditions with Juxtaposed Histograms

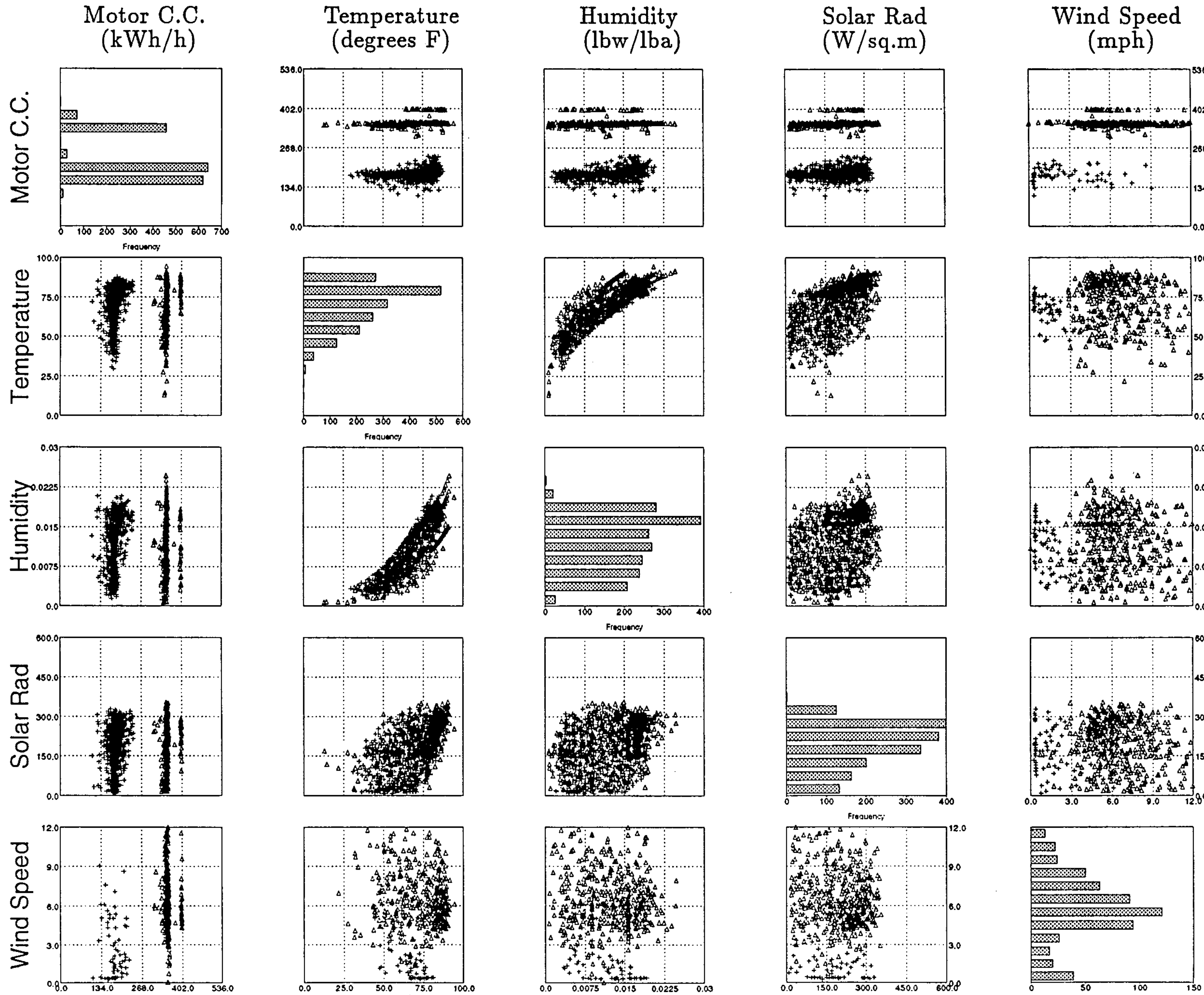
# Zachry Engineering Center (ZEC)
# Daily Average Values

Pre-Retrofit (△) 05/31/1989 - 11/28/1990 Post-Retrofit (+) 03/06/1991 - 12/31/1994



# Zachry Engineering Center (ZEC)
# Daily Average Values

Pre-Retrofit (Δ) 05/31/1989 - 11/28/1990 Post-Retrofit (+) 03/06/1991 - 12/31/1994

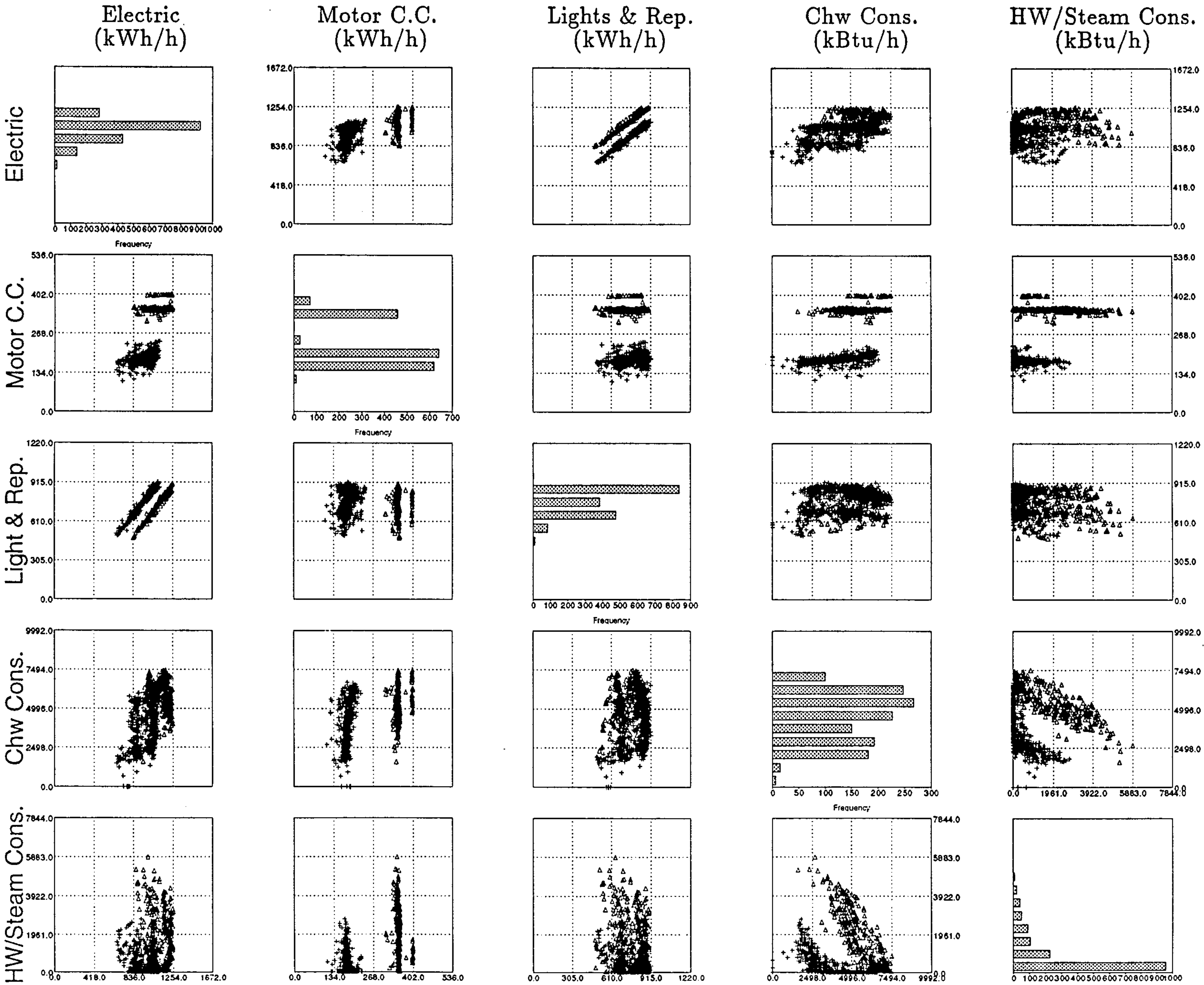


## Tab D-8

## Carpet Plots of One Energy Channel Use Against Other Energy Use Channels

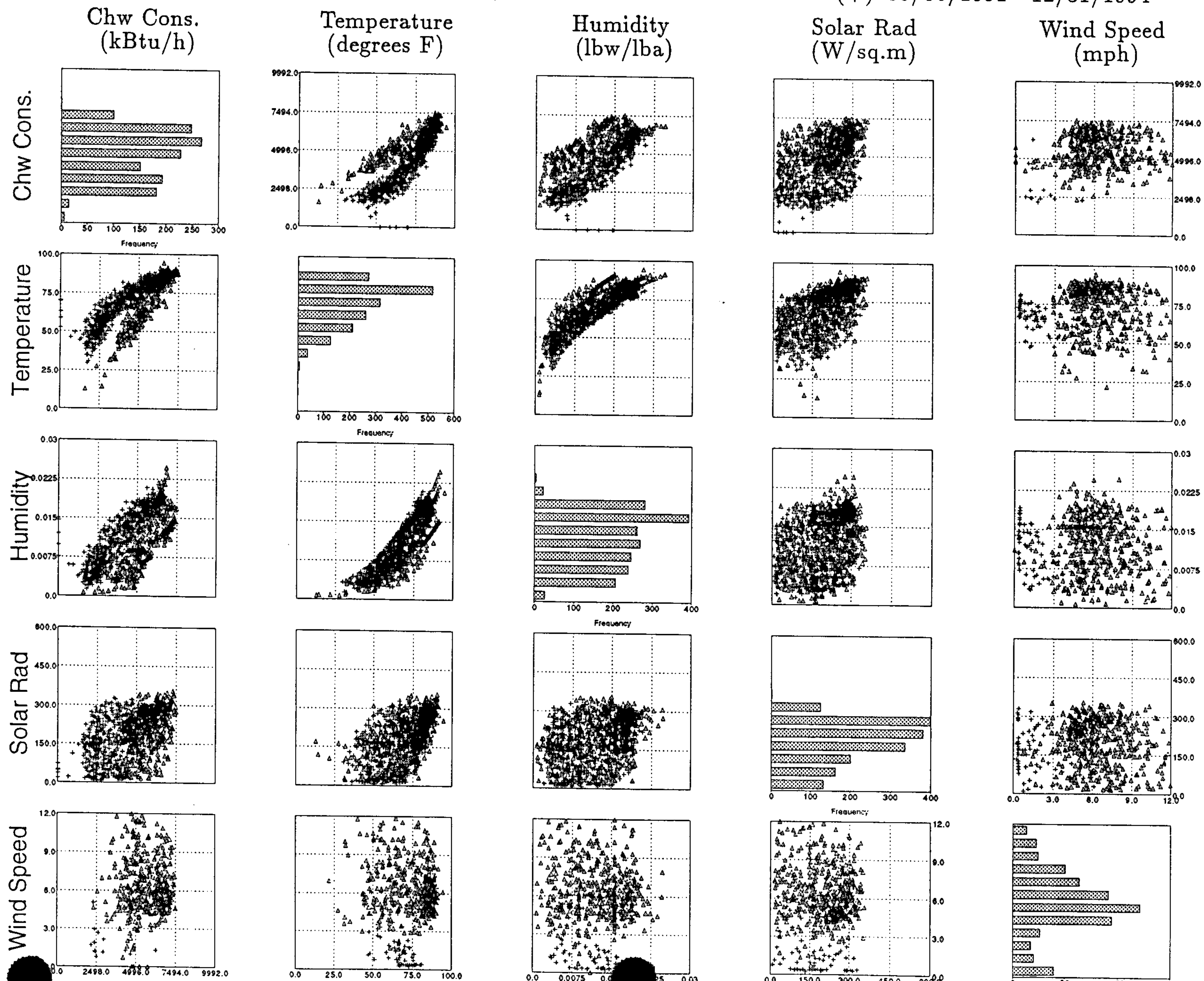
# Zachry Engineering Center (ZEC)
## Daily Average Values

Pre-Retrofit (Δ) 05/31/1989 - 11/28/1990 Post-Retrofit (+) 03/06/1991 - 12/31/1994



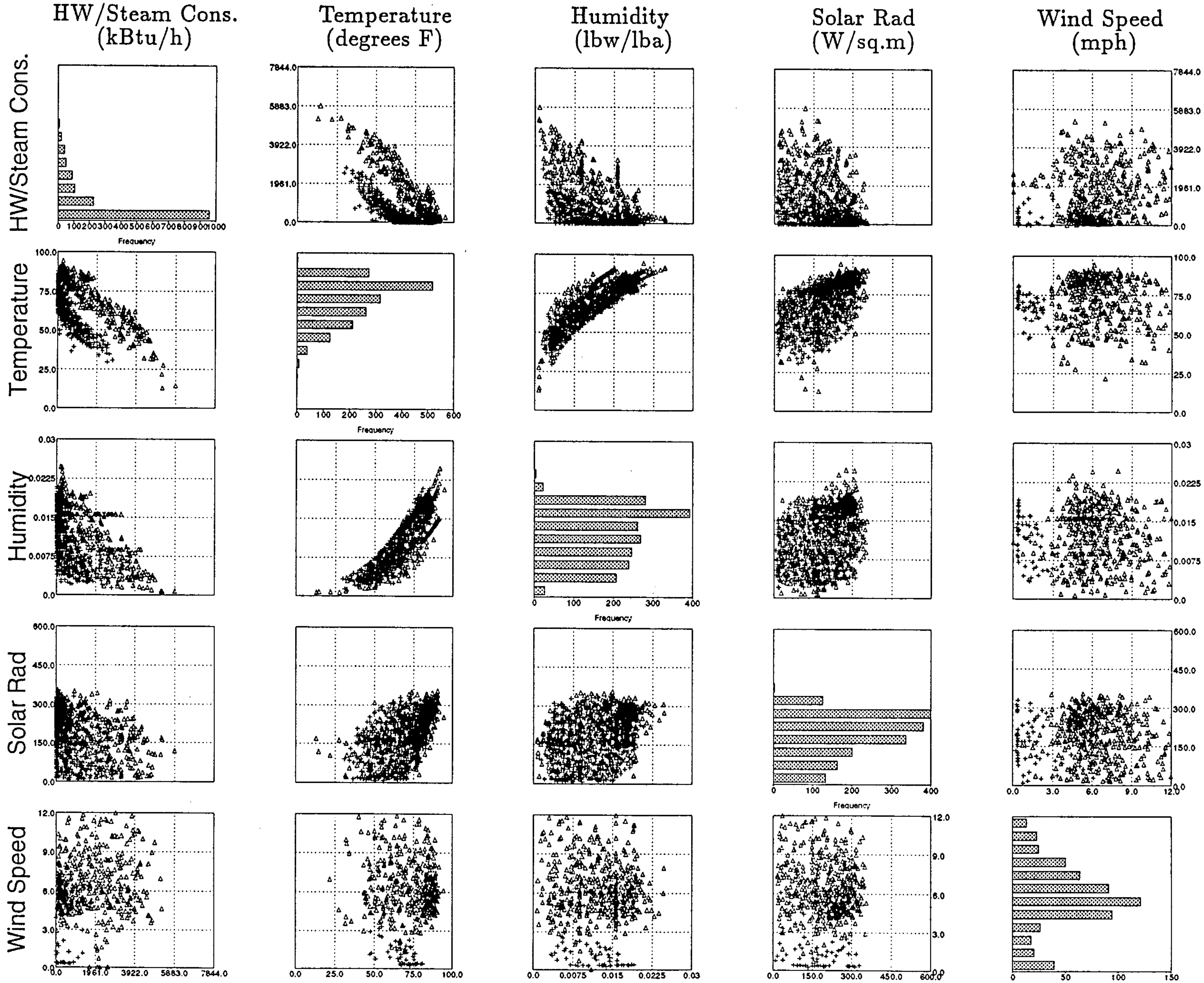
# Zachry Engineering Center (ZEC)
# Daily Average Values

Pre-Retrofit (△) 05/31/1989 - 11/28/1990 Post-Retrofit (+) 03/06/1991 - 12/31/1994



# Zachry Engineering Center (ZEC)
# Daily Average Values

Pre-Retrofit (Δ) 05/31/1989 - 11/28/1990 Post-Retrofit (+) 03/06/1991 - 12/31/1994

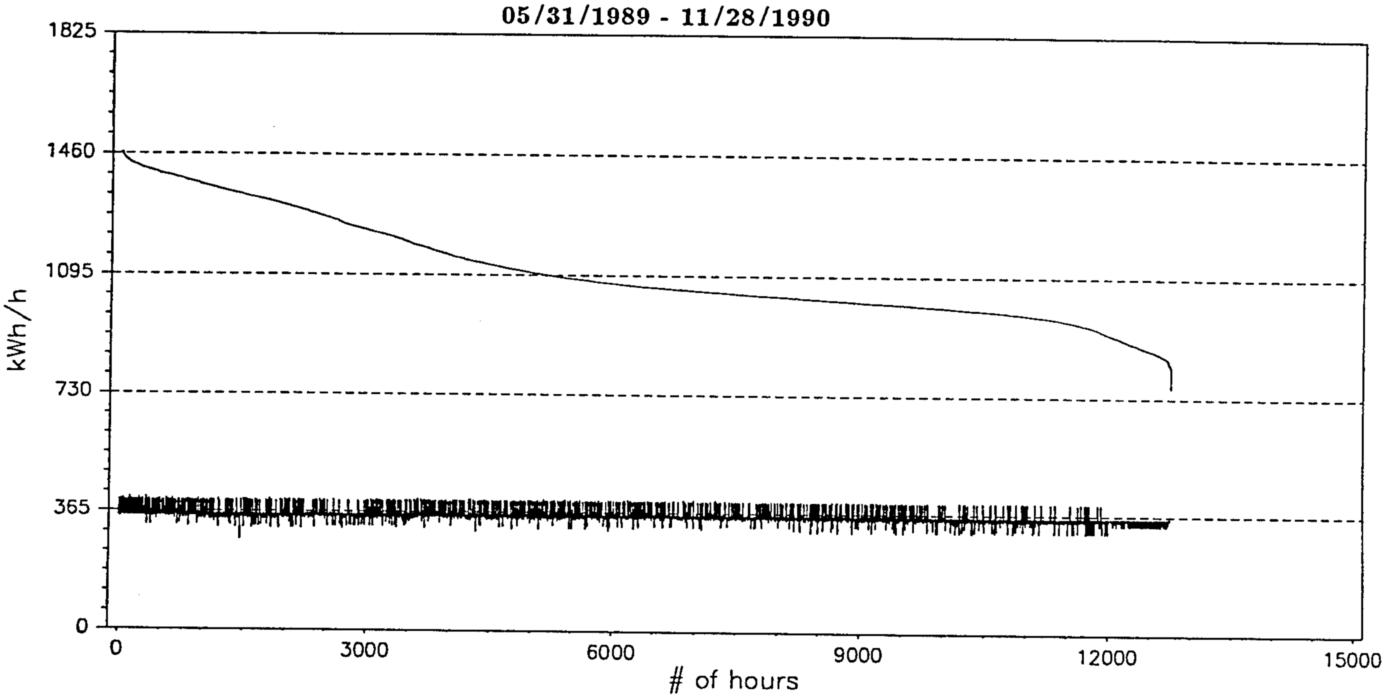


## Tab D-9

## Coincident Cumulative Frequency Plots

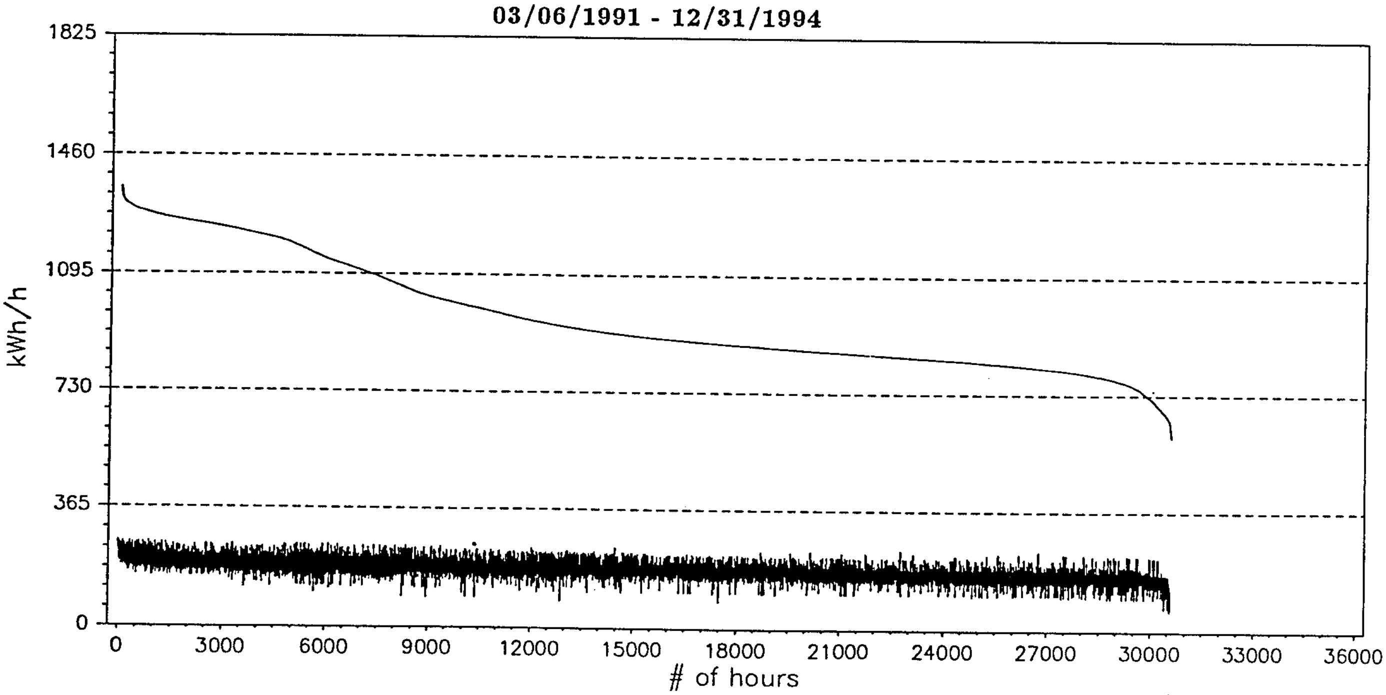
# Zachry Engineering Center (ZEC)
# W.B. Electric & M.C.C. as kWh/h

## Pre-Retrofit Period
**05/31/1989 - 11/28/1990**




upper line = W.B. Electric
lower line = M.C.C.

## Post-Retrofit Period
**03/06/1991 - 12/31/1994**




upper line = W.B. Electric
lower line = M.C.C.