ENERGY CONSERVATION OPPORTUNITIES IN COMMERCIAL AND INDUSTRIAL FACILITIES: ENERGY UTILIZATION INDICES (EUI) IN TEXAS LoanSTAR BUILDINGS

A Report

by

MICHAEL LEE PHILLIPS

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 1993

Major Subject: Mechanical Engineering

ENERGY CONSERVATION OPPORTUNITIES IN COMMERCIAL AND INDUSTRIAL FACILITIES: ENERGY UTILIZATION INDICES (EUI) IN TEXAS LoanSTAR BUILDINGS

A Report

by

MICHAEL LEE PHILLIPS

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 1993

Major Subject: Mechanical Engineering

ENERGY CONSERVATION SURVEY REPORT

Prepared by:

Mike Phillips (Student)
Jim Eggebrecht (Student)
Michaela Abraham (Student)
Norman Muraya (Student)
Namir Saman (Staff)
Warren Heffington (Staff)

Report No. 93-177

Energy Analysis and Diagnostic Center
Mechanical Engineering Department
Texas A&M University
College Station, Texas 77843-3123

Principal Products:
Insulated Wire (SIC 3357)
Geophones (SIC 3812)
Geophysical Instruments (SIC 3829)

Funded by:

United States Department of Energy

Prime Contractor:

University City Science Center
Philadelphia, Pennsylvania

Audit Date : 1/19/93
Report Date: 3/8/93

TABLE OF CONTENTS

ACKNOWLEDGMENT

Portions of this report have been adapted from energy analyses performed by Energy Analysis and Diagnostic Centers (EADC) at numerous institutions under contract to the University City Science Center. We gratefully acknowledge their contributions.

DISCLAIMER

The contents of this report are offered as guidance. The University City Science Center, Texas A&M University, and all technical sources referenced in this report do not (a) make any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report; or that the use of any information, apparatus, method, or process disclosed in this report may not infringe on privately owned rights; (b) assume any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report. This report does not reflect official views or policy of the above mentioned institutions. Mention of trade names or commercial products does not constitute endorsement or recommendation of use.

PREFACE

The work described in this report was performed under the direction of the Energy Analysis and Diagnostic Center (EADC) at Texas A&M University. The EADC program is managed by University City Science Center under agreement with the U.S. Department of Energy, which financially supports the program.

The objective of the EADC is to identify, evaluate, and recommend--through analyses of an industrial plant's operations--opportunities to conserve energy and reduce its cost. Our recommendations are based upon observations and measurements we made in your plant; because our time was limited, we do not claim to have complete detail on every aspect of the plant's operations. At all times we try to offer specific and quantitative recommendations of cost savings and energy conservation to the plants we serve. We do not attempt, however, to prepare engineering designs or otherwise perform services you would expect from an engineering firm, a vendor, or a manufacturer's representative. When the need for that kind of assistance arises, we urge you to consult them directly. If, however, you would like to discuss the content of the report or if you have another question about energy use, please feel welcome to contact us at the EADC at (409) 845-5019.

EXECUTIVE SUMMARY

Our energy analysis of your plant shows the annual energy bill from November, 1991, through October, 1992, for electricity and natural gas to be $299,494.71. You have an immediate potential for annual savings of $19,480. This is an seven percent reduction of your annual utility cost. Estimated costs for implementation of the six recommended energy conservation opportunities (ECOs 1 through 6) are $48,195 yielding an average simple payback of 2.5 years.

Your annual energy consumption and costs can be summarized as follows:

Electricity[1]	4,199,728 kwh	14,329 million Btu	$289,087.11
Natural Gas[2]	2,221 MCF	2,288 million Btu	$ 10,407.60
Total		16,617 million Btu	$299,494.71

The energy conservation opportunities (ECOs) recommended and outlined in this report could result in an estimated annual savings of 37,575 kwh/yr of electrical energy, a savings of 82 KVA●mo/yr of electrical demand, and an annual savings of 774 MCF/yr of natural gas. The energy related savings are worth about $5,800/yr. There is an additional cost savings of $12,900/yr due to meter consolidation in combination with changing to the LGS rate schedule and a cost savings of $790/yr resulting from sales tax exemption on your natural gas usage. The total annual energy savings of your facility would be 907 million Btu/yr or five percent of your annual energy consumption.

---

1 Includes energy charge, demand charge, and any riders

2 Includes any monthly service charge

Due to the size of your plant and the limited time we could spend there, most of the values used in the calculations for this report are estimated. Although these figures represent our best estimates of your potential saving and costs, you may want to consult other sources and verify these estimates before deciding to implement the ECOs with which they are associated. We welcome inquiries and further discussions of any information in this report.

In summary, your plant has the potential for an annual savings of $19,480. The individual ECOs are summarized in Table 1 and each is described in this report. In order to determine the success of our energy conservation program, we would like to discuss with you, perhaps within the next six months, your opinion of this report and how many of our suggestions you have decided to implement.

Table 1

Summary of Recommended Energy Conservation Opportunities

ECO #	Description of ECO	Type of Energy Conserved	Conserved Electric. Energy (kwh/yr)	Electrical Demand Saved (KVA•o/yr)	Energy Conserved Saved (MCF/yr)	Energy Conserved (mill.Btu/yr)	Estimated Savings ($/yr)	Implement Cost ($)	Simple Payback (yrs)
1.	Meter consolidation	----------	------	------	-----	-----	12,900	40,000	3.1
2.	Air conditioner management	Electrical	19,345	------	763	834	4,310	6,150	1.4
3.	Delamping	Electrical	12,100	82	-----	41	1,160	475	0.4
4.	Replace incandescent lamps	Electrical	4,260	------	-----	15	190	570	3.0
5.	Natural gas sales tax exemption	----------	------	------	-----	-----	790	1,000	1.3
6.	Close fume hood	Electrical	1,870	------	11	17	130	------	immed.
	Overall Totals		37,575	82	774	907	19,480	48,195	
	Overall Average								2.5

SUMMARY OF PLANT STATISTICS

PLANT DATA:

Report No: 92-177 SIC NO.: 3357, 3812, 3829 Location: [redacted] TEXAS

Principal Products: Geophysical Products - geophones, connectors, and cables

Annual Sales: $ 20 Million

Annual Production: 100,000 geophones and hydrophones, 50,000 connectors, and 200,000 feet of cable.

No. of Employees: 150 Date of Site Visit: January 19, 1993

Client Assistance: 14 hrs. Estimated Value: $600

Degree Days: Heating 1,550 Cooling 2,760

Weather Conditions: Cloudy with rain, Temperature in the mid 60's

OPERATING HOURS:

Section or Building		hrs/yr
Building B	= [2 shifts/day × 8 hrs/shift] × [5 days/wk × 52 wks/yr - 11 holidays/yr]	= 3,984 hrs/yr
Building A	= 8 hrs/day × [5 days/wk × 52 wks/yr - 11 holidays/yr]	= 1,992 hrs/yr

ENERGY CONSUMPTION:

Avoided Costs for November, 1991 to October, 1992:

Building B
Electrical Energy : $0.028/kwh
Demand : $13.15/KVA●mo

Building A: Addition (Plastic Molding Area)
Electrical Energy : $0.054/kwh
Demand : $5.90/KVA●mo

Building A: Original (Remaining Building Area)
Electrical Energy : $0.041/kwh
Demand : $9.32/KVA●mo

Natural Gas : $4.69/MCF

Source	Units	million Btu	Cost $	Cost $/ million Btu
Electricity[1]	4,199,728 kwh/yr	14,329	289,087.11	$20.17
Natural Gas	2,221 MCF/yr	2,288	10,407.60	$ 4.55
TOTALS		16,617	299,494.71	

[1] Includes energy charge, demand charge, and any riders. The cost is for MGS service.

PLANT BACKGROUND

General

This plant specializes in the manufacturing of geophysical products and industrial cables for remote operated underwater vehicles (ROV). There are two buildings at this plant location: the Geophysical Product facility in Building A, which manufactures geophones, hydrophones, takeouts, connectors and support cables, including the plastic molds, leader wires and heat treatment of springs in support of these products; and the Industrial Cable Product facility in Building B, which manufactures umbilical and tether cables for the ROV, and supplies wires and cables used by the Geophysical Product facility.

The plant's utility services include three electric meters and two natural gas meters. The electricity is supplied by Houston Lighting & Power (HL&P) while the natural gas is supplied by ENTEX. There are 150 employees and gross annual sales are approximately 20 million dollars. The Geophysical Product facility operates one, eight-hour shift per day, five days per week. The Industrial Cable Product facility operates two, eight-hour shifts per day, five days per week. There are two 15-minute breaks and a 30-minute lunch break in each shift. This plant takes eleven annual holidays. Weekend and holiday work is negligible.

Facility Description

Both Building A and Building B each cover approximately 50,000 ft^2 with Building A having 16-ft high walls and Building B having 20-ft high walls. Building A consists of an office area, geo/hydrophone assembly area, plating and etching laboratory, design and test area, take-outs and terminations assembly area, cable plastic molding area, plastic and rubber molding area, and warehousing and other administrative support areas. Building B houses the machine shop, cable coating area (extruders), cable twisting area, braiding area, cable area (multiple twisted pairs machines), hot boxes and a stockroom. This plant's layout is illustrated graphically in Figure 1 and major energy using equipment is shown in Table 2.

Process Description

The plant maintains an inventory of over 26,000 items. The process flow varies depending upon customer orders, with most products being custom developed to satisfy a customer's order by utilizing as much available inventory and standard designs as feasible.

Industrial Cable Process:

The primary raw materials in this process is copper wire and polyethylene. Bare wire enters an extruder and receives a primary coat of polyethylene. The coated wire will then be twisted into a cable pair in the twisting area. Multiple twisted pairs may be sent to the cabling area to be twisted into larger sized cables. Finally, the twisted larger sized cable receives a secondary coat of extruded polyethylene. Depending on the product required, the wire may exit at any point or the process may be repeated several times, resulting in a final product with several smaller cables twisted together and coated, and possibly additional cables or twisted pairs twisted around the group and then again coated with polyethylene.

Figure 1: Plant Layout

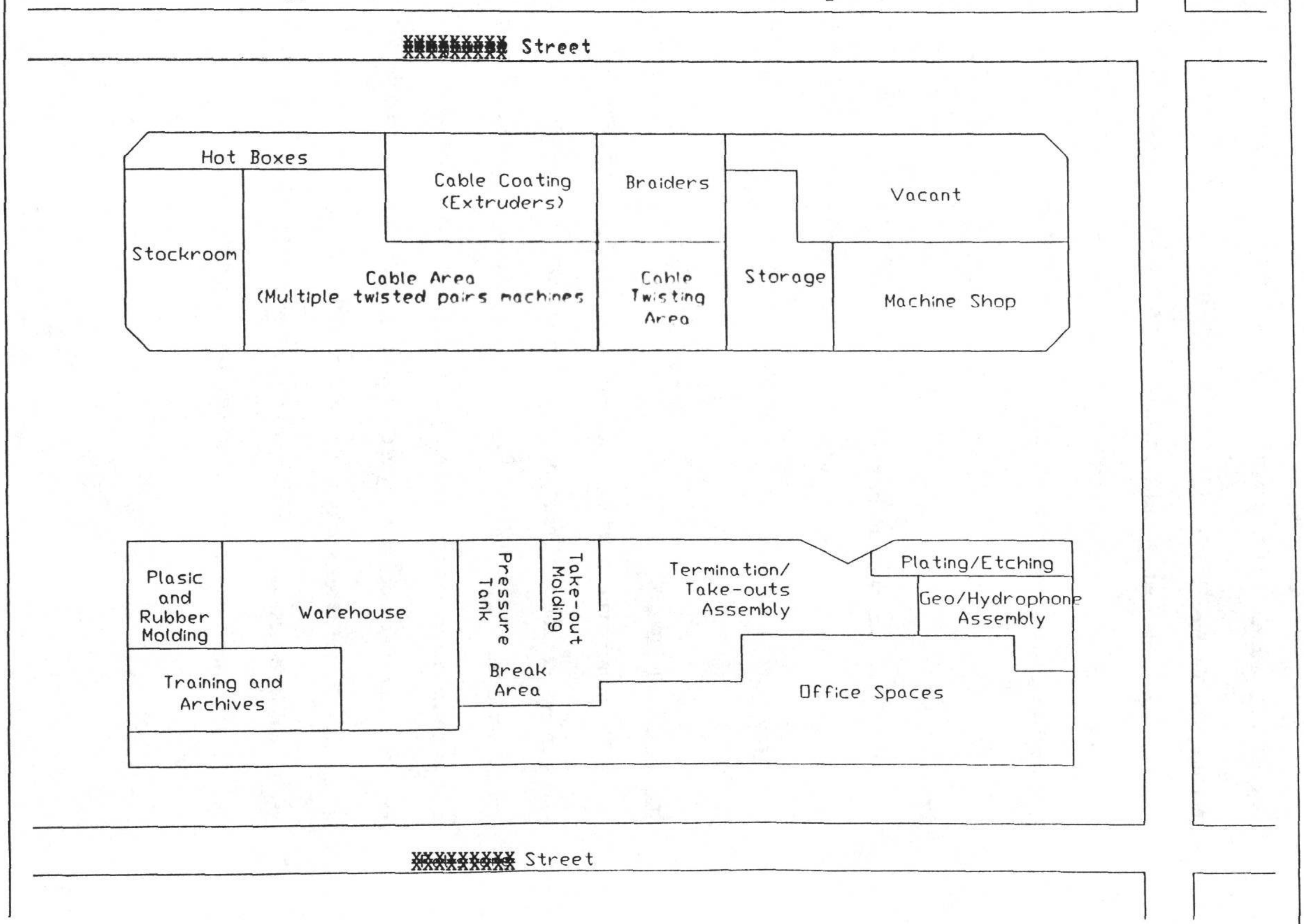


TABLE 2:

MAJOR ENERGY USING EQUIPMENT[1]

Area & Equipment	(hp)	Rated Power (Volts)	(Amps)	Estimated Efficiency	Estimated Load Factor	Quantity	Operation hours (hrs/yr)
Building A: Geophysical Products							
Injection Molder		440	16.5 to 48.0		0.9	10	2,075
Injection Heater		460	72.0		0.9	1	2,075
Injection Console		440	46.0		0.9	3	2,075
Pressure Tank #8		460	40.0		0.9	1	1,030
Polyjector		240	24.0		0.9	1	4,152
Pressure Tank Heater		208	28.8		0.9	1	3,505
Plating Machine		240	50.0		0.9	1	8,760
A/C Compressors		460	21.3		1.0	17	1,296
A/C Compressors		460	50.0		1.0	2	1,296
A/C Compressors		460	24.0		1.0	2	1,296
Building B: Industrial Cables							
Tubers	40dc			0.915	0.85	1	1,220
Respooler	10dc			0.915	0.85	2	2,190
Cabler #1	30dc			0.915	0.85	1	2,820
Cabler #2	10dc			0.915	0.85	1	10
Cabler #3	40dc			0.915	0.85	1	715
Cabler #6	30dc			0.915	0.85	1	1,060
Extruder #3	40dc			0.915	0.85	1	1,235
Extruder #4	100dc			0.915	0.85	1	5,950
Extruder #8	60dc			0.915	0.85	1	3,560
Extruder #6/7	40dc			0.915	0.85	2	2,490
Take-up #3	10dc			0.915	0.85	1	3,560
Hot Box		480	100.0		0.85	1	8,760
A/C Compressors		208	61.6		1.0	6	1,296
A/C Compressors		208	27.0		1.0	16	1,296

[1] Information contained in this table was obtained from the "Predominant Use Study" by Gator Engineering, May 1992 and from motor name plate data.

Hot boxes (natural gas heated convection ovens about 10' × 10' × 30') are used to preheat resins as well as to dehumidify the cable prior to the secondary extruder process when necessary. A machine shop is used to maintain the existing equipment.

Geophysical Products:

These products may be divided into cables for relaying geophysical signals and non-cable products. A primary supply for the cable are the cables and wires produced in the other facility. Another major raw material is plastic for molding such items as connector assembly parts. Cable is respooled and cut to the customer's desired length. The cable then enters the take-out/termination assembly area where a wire pair within the cable is "taken-out" at pre-determined intervals. These "take-outs" become connection points for sensors. Each cable will have several take-outs, depending on the cable size and the customer's order.

Connections between the cables are called terminations. The cable with the take-outs and terminations are taken to a vertical injection molding machine where a water tight seal is molded around the exposed wires and connector assembly. The cable can then be used to transmit signals from sensors attached at the take-outs to a central location for processing.

Non-cable geophysical products such as geophones, hydrophones, connectors, and amplifiers are also assembled in this building. These products are used in conjunction with the take-out cable as described above. A plating/etching laboratory produces sensitive springs from thin copper sheets for use in several of the monitoring products. The products are hand assembled and sent to the plastic and rubber molding area for final water tight casing. An engineering testing laboratory is available as well as a pressure tank to respond to customer's requests.

Waste Products

The primary waste products is copper. Cable lengths shorter than 750 feet are too small for most customer orders and are usually scrapped. Copper waste amounts to about 45,000 pounds per year. Plastic waste is reground and used again.

Energy Conservation Practices Implemented

This facility has never undergone a formal energy audit before. There were several existing good energy management practices we observed or discussed with plant personnel on the day of the audit.

- A proposal to correct the power factor for each facility has been forwarded for approval and funding. Past experience has indicated that power factor correction will provide a payback period of about two years or less.
- A proposal to install programmable thermostats was received from an outside vender but not acted upon. ECO #2 addresses this option.
- High efficiency, high output fluorescent lighting is in use in both facilities.

Energy Conservation Opportunities not Included:

- Building insulation repair and installations: Various locations in Building A and B have missing or damaged ceiling insulation. Our estimated simple payback for this ECO was over 44 years and therefore this ECO was not included in this report.

- Insulate injection machines: An acceptable insulating blanket could not be found for the smaller machines in use in this plant.
- Energy efficient motors: According to a GE technical representative, energy efficient dc motors are cost prohibitive. The higher efficiency would not offset the higher cost of the motor on any reasonable time scale.
- Energy efficient lubricants: Only three motors were located in your plant which were not self lubricating. Because of the small number of motors, this ECO would have cost savings, but they would be small (less than $100/yr).
- Avoid paying late fees on electric bills: By avoiding late fees, a savings of $249 would have been realized during the twelve month period evaluated in this report.

ENERGY MANAGEMENT

Rising energy costs and repeated energy shortages will determine the future of many companies. To meet this challenge, a successful company must have an energy management program to consistently take advantage of energy conservation opportunities. Several basic steps are required for effective energy management:

- Management Commitment
- Data Analysis
- Goal Setting
- Analysis of Conservation Opportunities
- Implementation of Conservation Techniques
- Continued Feedback and Analysis

An energy management program must have the commitment of management to produce a long-term increase in energy efficiency. A brief, early show of support produces only small, temporary improvements. Management must design the conservation program as part of its regular, overall company management system. Also, energy cost and the consequences of future energy shortages should be widely disseminated to create total energy awareness.

Information must be recorded regularly to support the energy management program. Utility bills and production records may already contain much of the necessary information. Existing sources are adequate to calculate overall energy costs and determine production efficiency in terms of how much energy is required to manufacture one unit of production, but probably not adequate to detail energy use in each production step. The information base must be designed for detailed breakdown of energy consumption as data become available.

Data analysis is facilitated if records employ a standard format for all the company divisions and if the various energy units (e.g.,kilowatt-hours of electricity, gallons of oil) are converted to a common energy unit, the Btu (British Thermal Unit). One Btu is the amount of energy needed to raise the temperature of one pound of water one degree Fahrenheit. Comparison of the costs of fuels on the basis of cost per million Btu ($/million Btu) reveals the true cost of each fuel. The conversion factors are:

ENERGY UNIT	BTU CONVERSION
1 kwh	3,412 Btu
1 Cubic Foot *	1,030 Btu
1 Gallon #2 Oil	140,000 Btu
1 Gallon #6 Oil	152,000 Btu
1 Gallon Propane	91,600 Btu
1 Ton Coal	28,000,000 Btu
1 Gallon Regular Gasoline	130,000 Btu
1 Gallon Kerosene	138,000 Btu
1 lb Wood shavings(saw dust)	4,375 Btu

Examine progress toward conservation goals regularly, monthly or annually, and define a new set of goals. All goal settings depend on the opportunities for energy conservation that data analysis uncovers. More detailed information on specific mechanisms may be needed as the program continues the search for energy waste.

* Estimated average Btu value.

PLANT ENERGY CONSUMPTION

The energy consumption of this facility consists of electricity, which enters the facility via three meters, and natural gas, which enters the facility via two meters. The electricity for this facility is serviced by Houston Lighting and Power (HL&P) under the Miscellaneous General Service (MGS) rate schedule. The electrical energy consumption data in this report is from November, 1991 to October, 1992. The total charges for electrical energy for the period were $142,237, $122,281 and $24,569 for meter numbers 994636 (Building B), W62181917 (Building A, original construction area) and S50954244 (Building A, addition), respectively, or $289,087 combined. Details of meter 994636 are tabulated in Table 3 and shown graphically in Figures 2 to 4. Details of meter W62181917 are tabulated in Table 4 and shown graphically in Figures 5 to 7. Details of meter S50954244 are tabulated in Table 5 and shown graphically in Figures 8 to 10.

The bills were calculated using the current rate schedule (a copy of the MGS rate schedule is included in Appendix A). The monthly charges were re-calculated for each month of data reflected in Tables 3, 4 and 5, and there were no apparent errors found.

The total cost of natural gas for this facility is $10,407/yr, details of which are tabulated in Table 6 and shown graphically in Figures 11 to 14.

Table 3: Summary of Electrical Consumption, Demand, and Cost

Houston Lighting & Power MGS Rate Schedule

Building B

Meter Number **994636**

Month	Billing Dates	Energy Consumed (kwh)	Size of Block 1 (kwh)	Consumption in Block 1 (kwh)	Size of Block 2 (kwh)	Consumption in Block 2 (kwh)	Consumption in Block 3 (kwh)	Demand (KVA)	Power Factor	PCRF Charge ($/kwh)	PCRF Cost ($)
Nov	11/11 - 12/10	142,400	64,500	64,500	87,720	77,900	0	516	0.75	-0.000003	-0.43
Dec	12/10 - 01/10	122,400	48,000	48,000	65,280	65,280	9,120	384	0.79	0.000307	37.58
Jan	01/10 - 02/11	155,680	54,750	54,750	74,460	74,460	26,470	438	0.70	0.000307	47.79
Feb	02/11 - 03/11	167,200	64,500	64,500	87,720	87,720	14,980	516	0.72	0.000307	51.33
Mar	03/11 - 04/09	160,480	60,000	60,000	81,600	81,600	18,880	480	0.81	0.000307	49.27
Apr	04/09 - 05/11	183,040	63,625	63,625	86,530	86,530	32,885	509	0.75	0.000307	56.19
May	05/11 - 06/10	185,280	70,500	70,500	95,880	95,880	18,900	564	0.74	0.000307	56.88
Jun	06/10 - 07/13	275,040	81,250	81,250	110,500	110,500	83,290	650	0.76	0.000307	84.44
Jul	07/13 - 08/12	227,440	75,375	75,375	102,510	102,510	49,555	603	0.79	0.000307	69.82
Aug	08/12 - 09/10	201,200	72,750	72,750	98,940	98,940	29,510	582	0.80	0.000307	61.77
Sep	09/10 - 10/09	175,440	70,375	70,375	95,710	95,710	9,355	563	0.77	0.000307	53.86
Oct	10/09 - 11/10	188,560	60,500	60,500	82,280	82,280	45,780	484	0.84	0.000307	57.89
Totals		2,184,160	786,125	786,125	1,069,130	1,059,310	338,725	6,289			626.39
Average									0.77		

Month	Billing Dates	Fuel Cost Factor ($/kwh)	Fuel Cost Charge ($)	Facilities Charge ($)	Demand Charge ($)	Energy Charge ($)	Sub-Total ($)	Fuel Refund ($)	Late Charge ($)	Total cal'c Bill ($)	Actual Bill ($)
Nov	11/11 - 12/10	0.019924	2,837.18	29.25	1,720.40	6,029.06	10,615.46			10,615.46	10,615.46
Dec	12/10 - 01/10	0.019924	2,438.70	29.25	1,271.60	4,796.64	8,573.76	1,850.08		6,723.68	6,723.69
Jan	01/10 - 02/11	0.019924	3,101.77	29.25	1,455.20	5,588.66	10,222.68			10,222.68	10,222.67
Feb	02/11 - 03/11	0.019924	3,331.29	29.25	1,720.40	6,465.41	11,597.68			11,597.68	11,597.68
Mar	03/11 - 04/09	0.019924	3,197.40	29.25	1,598.00	6,050.50	10,924.42			10,924.42	10,924.42
Apr	04/09 - 05/11	0.019924	3,646.89	29.25	1,696.60	6,742.74	12,171.67			12,171.67	12,171.67
May	05/11 - 06/10	0.019924	3,691.52	29.25	1,883.60	7,343.06	13,004.31			13,004.31	13,004.31
Jun	06/10 - 07/13	0.018869	5,189.73	29.25	2,176.00	8,912.56	16,391.98			16,391.98	16,391.98
Jul	07/13 - 08/12	0.018869	4,291.57	29.25	2,016.20	8,065.45	14,472.29	1,841.13		12,631.16	12,631.16
Aug	08/12 - 09/10	0.018869	3,796.44	29.25	1,944.80	7,650.60	13,482.86			13,482.86	13,482.86
Sep	09/10 - 10/09	0.019924	3,495.47	29.25	1,880.20	7,260.49	12,719.26			12,719.26	12,719.27
Oct	10/09 - 11/10	0.019924	3,756.87	29.25	1,611.60	6,296.49	11,752.09			11,752.09	11,752.10
Totals			42,774.82	351.00	20,974.60	81,201.65	145,928.46	3,691.21	0.00	142,237.25	142,237.27

Figure 2: Electrical Energy Consumption

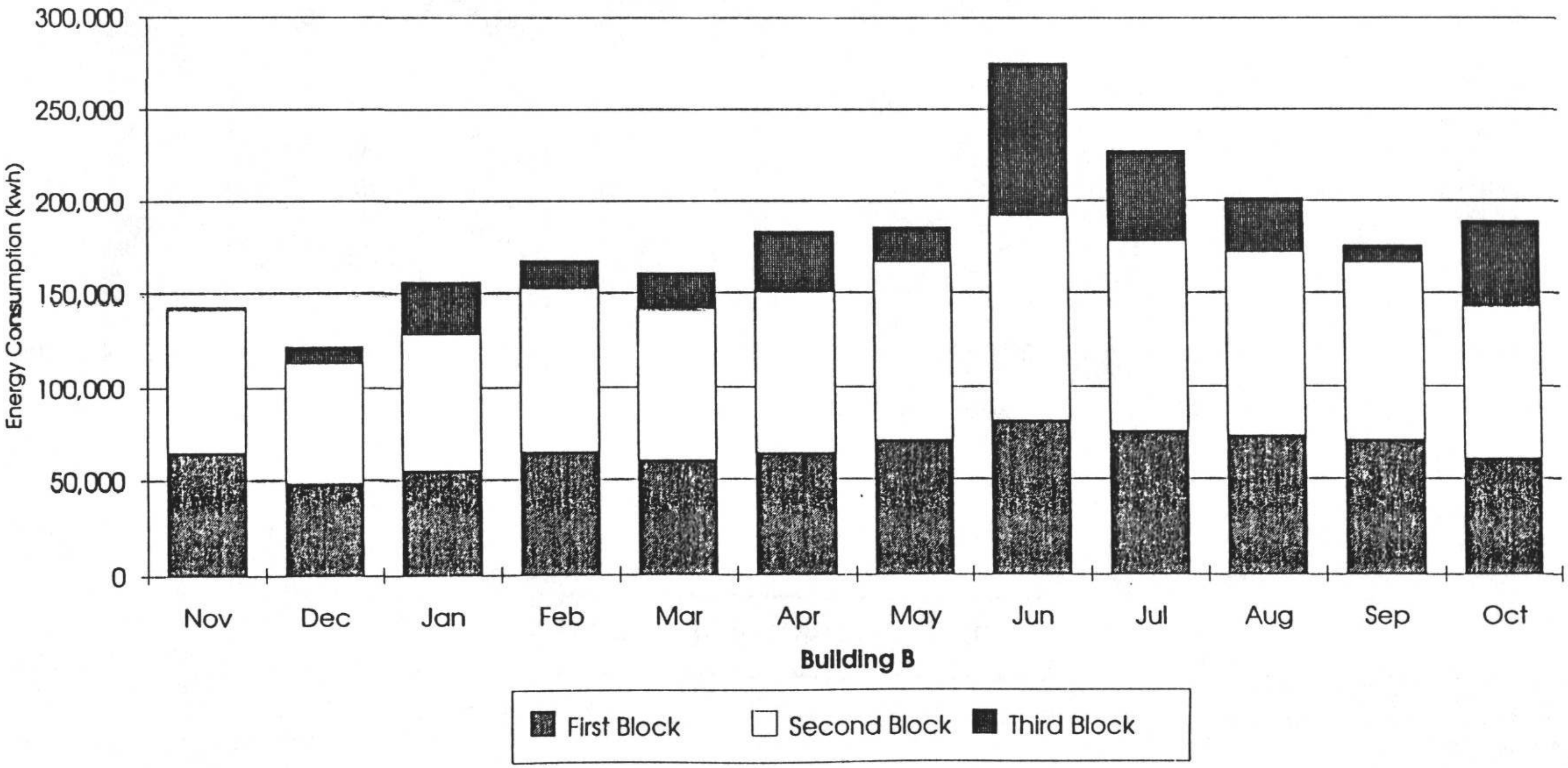


Figure 3: Electrical Demand

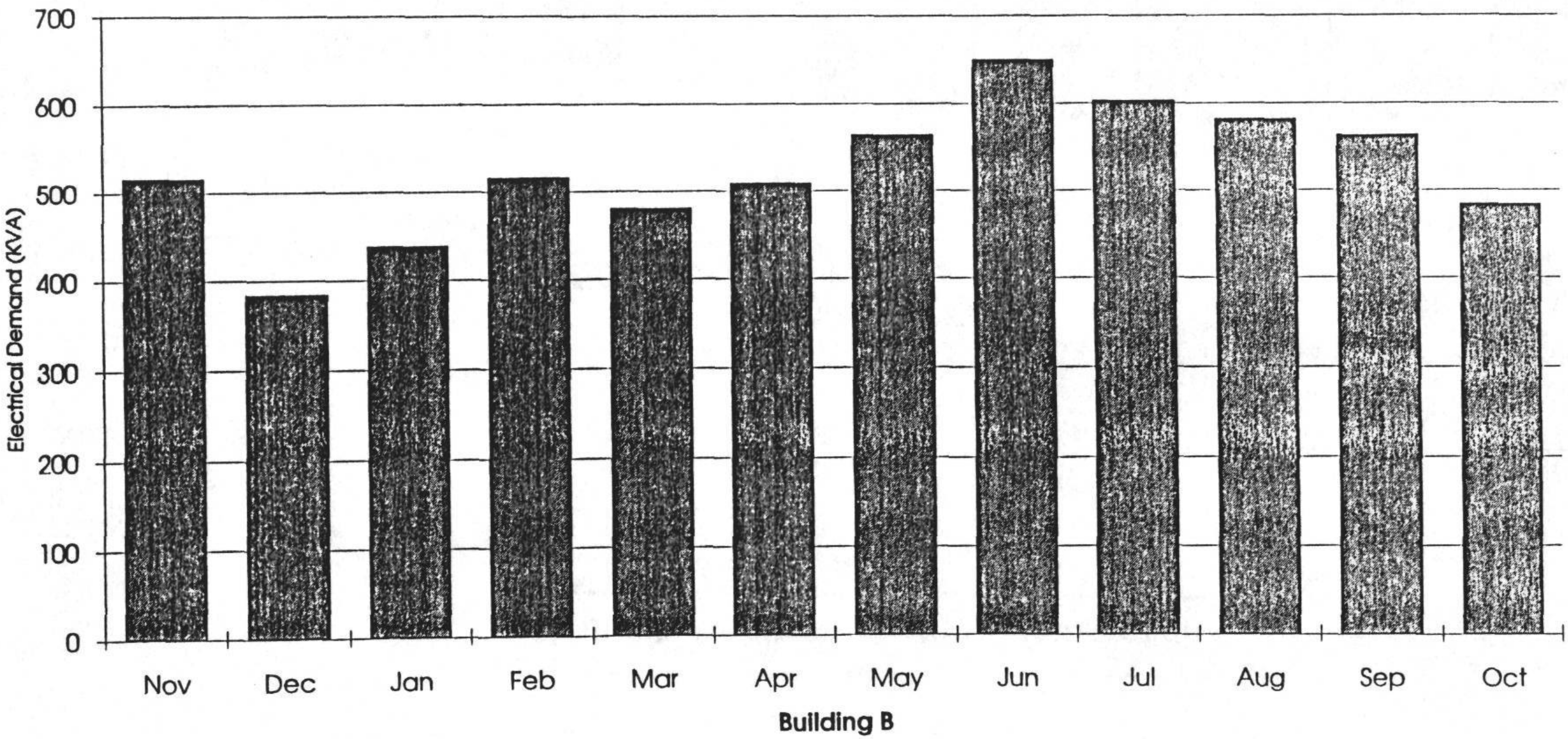


Figure 4: Electrical Energy Cost

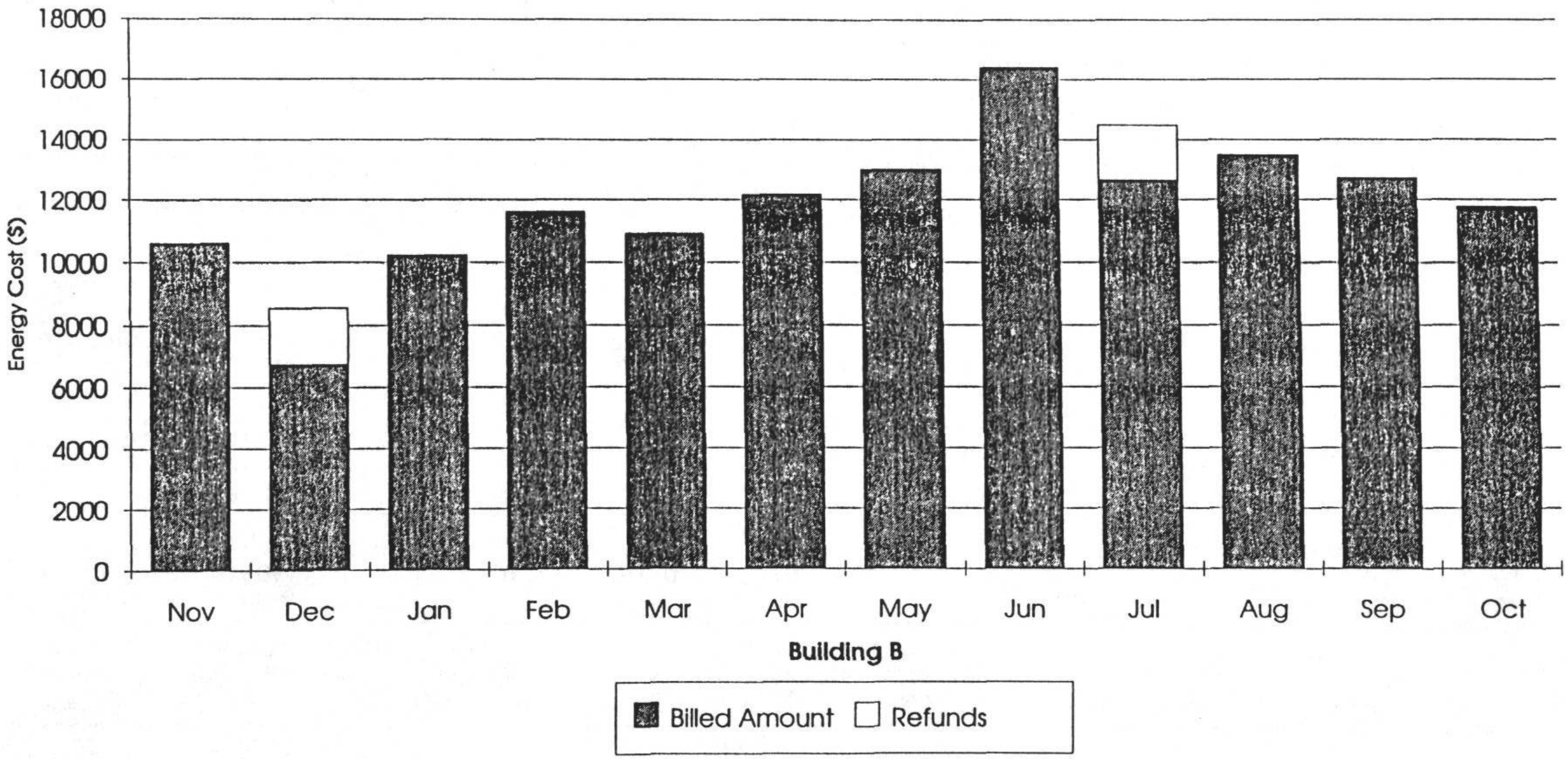


Table 4: Summary of Electrical Consumption, Demand, and Cost

Houston Lighting & Power MGS Rate Schedule

Building A: Original

Meter Number **W62181917**

Month	Billing Dates	Energy Consumed (kwh)	Size of Block 1 (kwh)	Consumption in Block 1 (kwh)	Size of Block 2 (kwh)	Consumption in Block 2 (kwh)	Consumption in Block 3 (kwh)	Demand (KVA)	Power Factor	PCRF Charge ($/kwh)	PCRF Cost ($)
Nov	11/11 - 12/11	131,616	55,750	55,750	75,820	75,820	46	446	NA	-0.000003	-0.39
Dec	12/11 - 01/15	116,064	50,375	50,375	68,510	65,689	0	403	NA	0.000307	35.63
Jan	01/15 - 02/13	111,456	54,000	54,000	73,440	57,456	0	432	NA	0.000307	34.22
Feb	02/13 - 03/12	117,216	54,000	54,000	73,440	63,216	0	432	NA	0.000307	35.99
Mar	03/12 - 04/13	134,496	54,000	54,000	73,440	73,440	7,056	432	NA	0.000307	41.29
Apr	04/13 - 05/13	137,664	57,625	57,625	78,370	78,370	1,669	461	NA	0.000307	42.26
May	05/13 - 06/12	169,920	64,750	64,750	88,060	88,060	17,110	518	NA	0.000307	52.17
Jun	06/12 - 07/13	184,032	64,750	64,750	88,060	88,060	31,222	518	NA	0.000307	56.50
Jul	07/13 - 08/11	172,800	68,375	68,375	92,990	92,990	11,435	547	NA	0.000307	53.05
Aug	08/11 - 09/10	168,192	68,375	68,375	92,990	92,990	6,827	547	NA	0.000307	51.63
Sep	09/10 - 10/09	150,048	68,375	68,375	92,990	81,673	0	547	NA	0.000307	46.06
Oct	10/09 - 11/09	132,192	61,250	61,250	83,300	70,942	0	490	NA	0.000307	40.58
Totals		1,725,696	721,625	721,625	981,410	928,706	75,365	5,773			488.99
Average									NA		

Month	Billing Dates	Fuel Cost Factor ($/kwh)	Fuel Cost Charge ($)	Facilities Charge ($)	Demand Charge ($)	Energy Charge ($)	Sub-Total ($)	Fuel Refund ($)	Late Charge ($)	Total cal'c Bill ($)	Actual Bill ($)
Nov	11/11 - 12/11	0.019924	2,622.32	29.25	1,482.40	5,493.97	9,627.54			9,627.54	9,627.55
Dec	12/11 - 01/15	0.019924	2,312.46	29.25	1,336.20	4,870.09	8,583.64	1,754.31		6,829.33	6,829.32
Jan	01/15 - 02/13	0.019924	2,220.65	29.25	1,434.80	4,789.25	8,508.17		204.88	8,713.05	8,713.05
Feb	02/13 - 03/12	0.019924	2,335.41	29.25	1,434.80	4,980.94	8,816.39			8,816.39	8,816.39
Mar	03/12 - 04/13	0.019924	2,679.70	29.25	1,434.80	5,372.78	9,557.82			9,557.82	9,557.82
Apr	04/13 - 05/13	0.019924	2,742.82	29.25	1,533.40	5,901.28	10,249.01			10,249.01	10,249.01
May	05/13 - 06/12	0.019924	3,385.49	29.25	1,727.20	6,742.34	11,936.45			11,936.45	11,936.45
Jun	06/12 - 07/13	0.018869	3,472.50	29.25	1,727.20	6,845.55	12,130.99			12,130.99	12,131.00
Jul	07/13 - 08/11	0.018869	3,260.56	29.25	1,825.80	7,071.31	12,239.97	1,398.82		10,841.15	10,841.15
Aug	08/11 - 09/10	0.018869	3,173.61	29.25	1,825.80	7,037.61	12,117.91			12,117.91	12,117.90
Sep	09/10 - 10/09	0.019924	2,989.56	29.25	1,825.80	6,611.06	11,501.73			11,501.73	11,501.73
Oct	10/09 - 11/09	0.019924	2,633.79	29.25	1,632.00	5,624.34	9,959.97			9,959.97	9,959.96
Totals			33,828.87	351.00	19,220.20	71,340.52	125,229.57	3,153.13	204.88	122,281.32	122,281.33

Figure 5: Electrical Energy Consumption

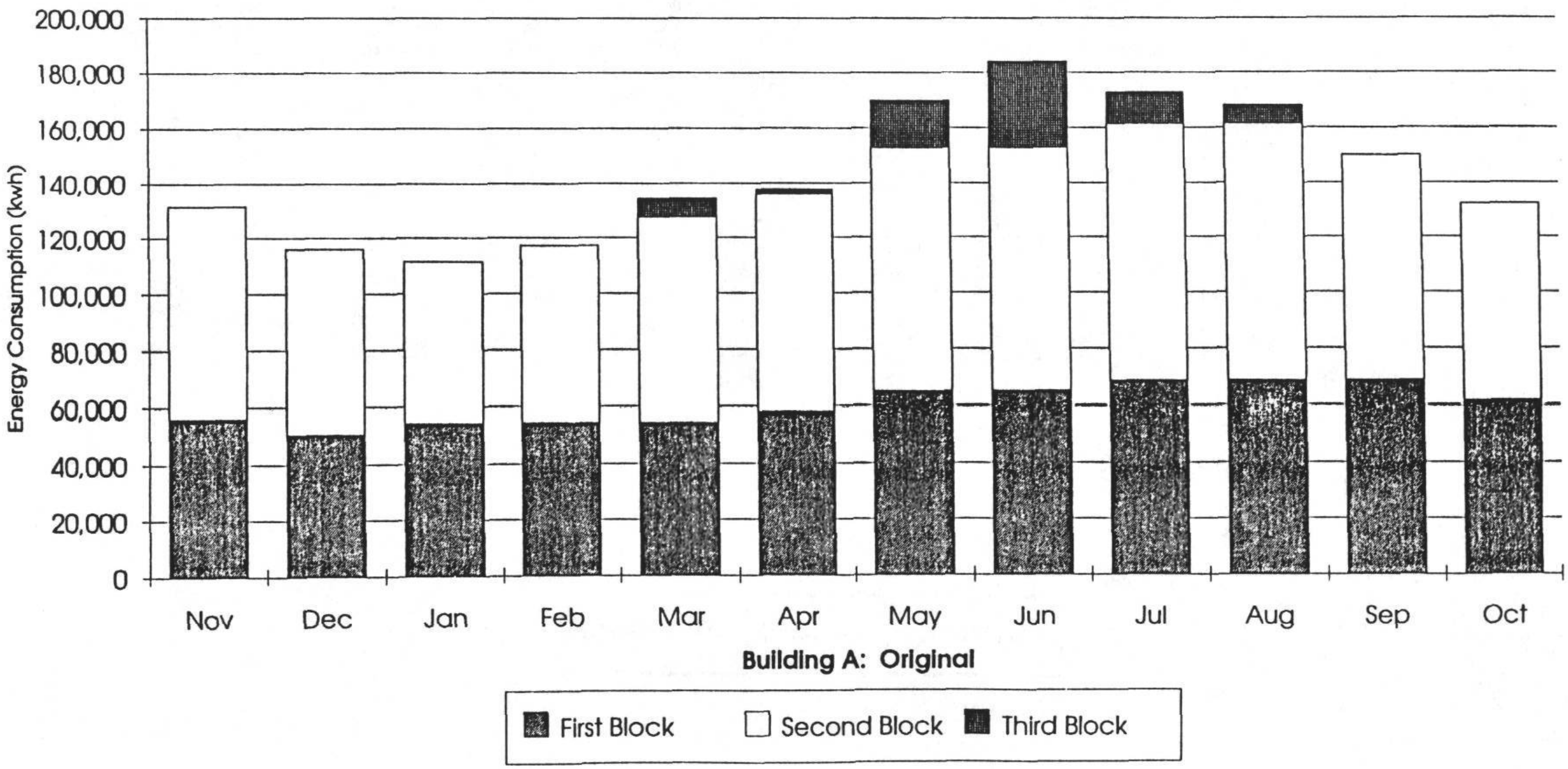


Figure 6: Electrical Demand

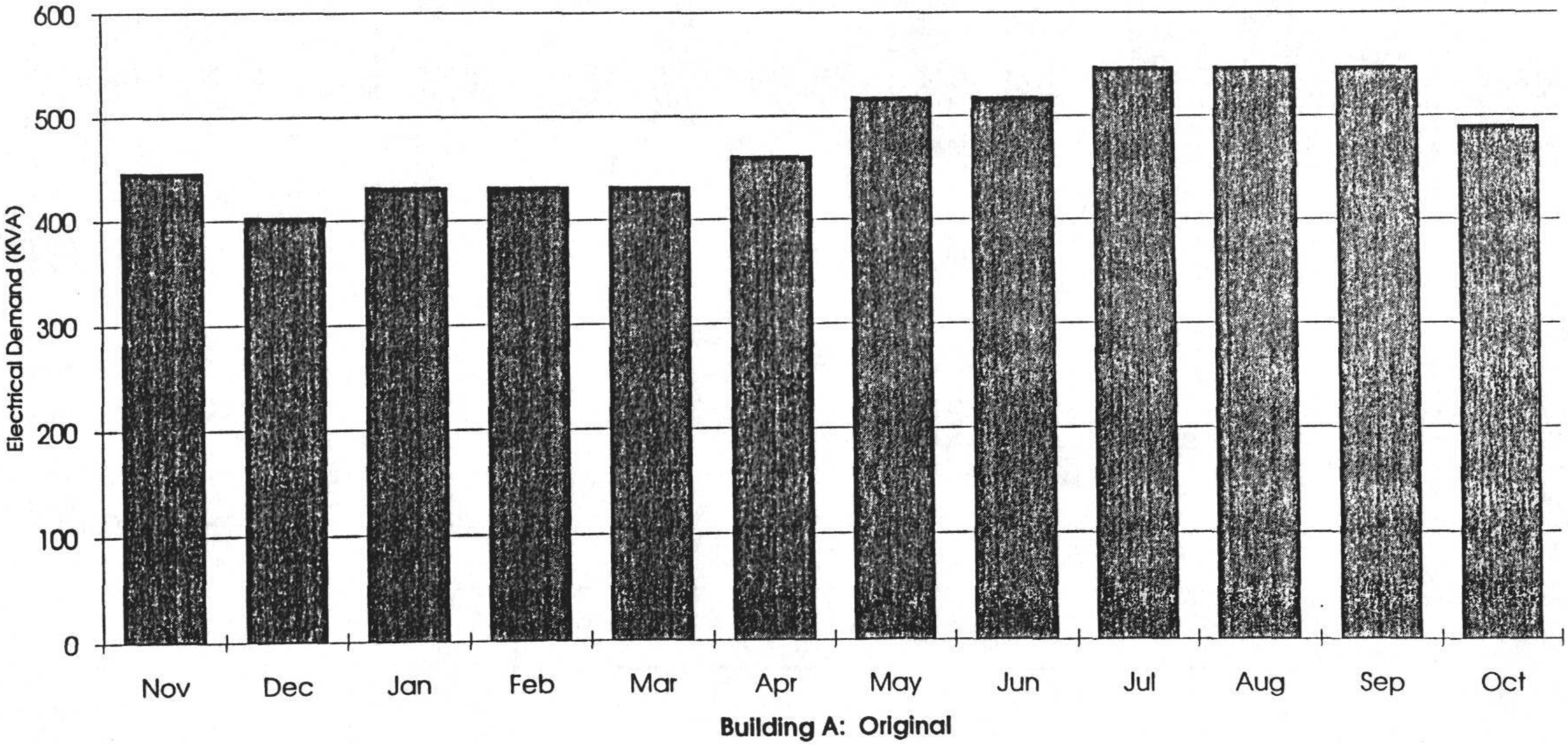


Figure 7: Electrical Energy Cost

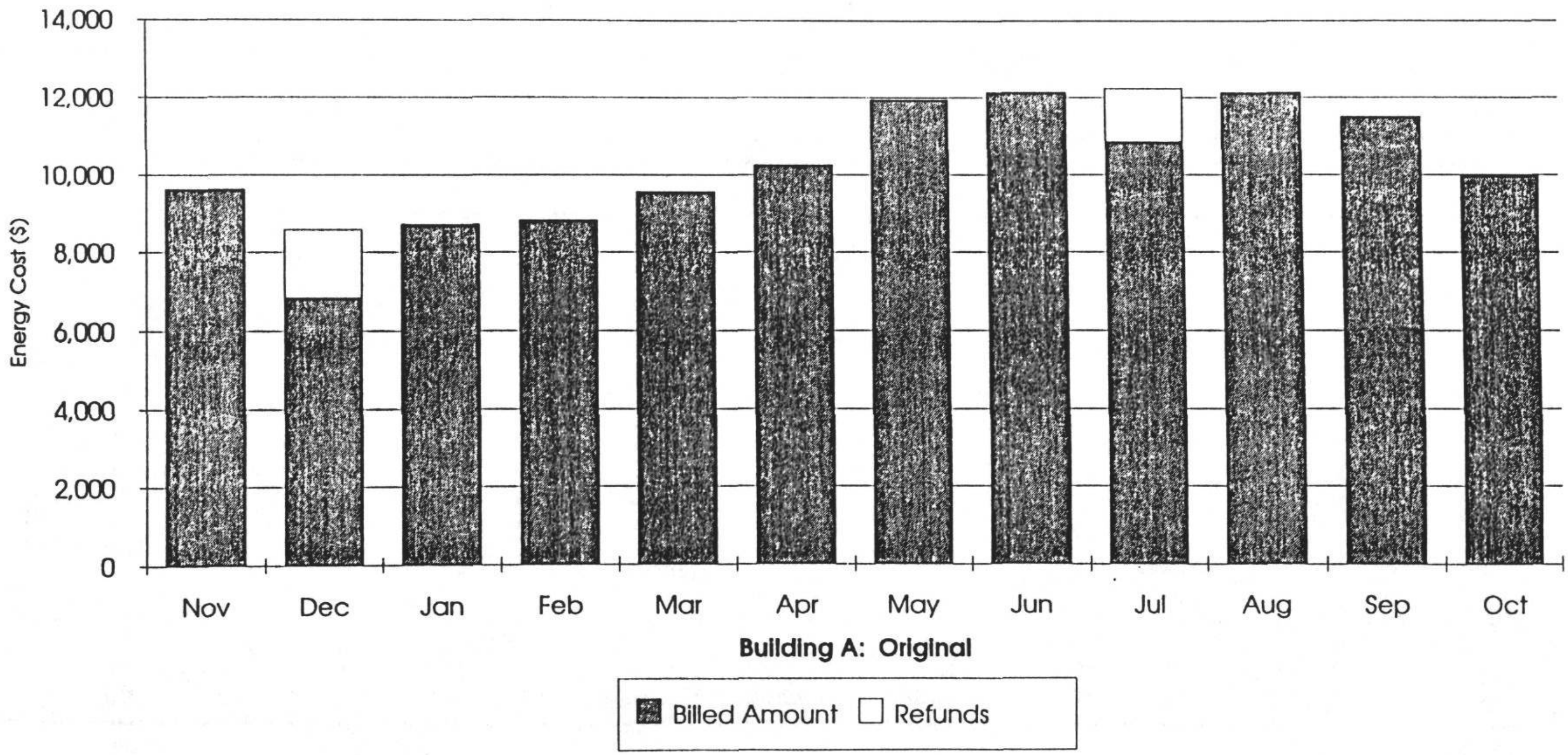


Table 5: Summary of Electrical Consumption, Demand, and Cost

Houston Lighting & Power MGS Rate Schedule

Building A: Addition

Meter Number **S50954244**

Month	Billing Dates	Energy Consumed (kwh)	Size of Block 1 (kwh)	Consumption In Block 1 (kwh)	Size of Block 2 (kwh)	Consumption In Block 2 (kwh)	Consumption In Block 3 (kwh)	Demand (KVA)	Power Factor	PCRF Charge ($/kwh)	PCRF Cost ($)
Nov	11/11 - 12/11	15,408	11,750	11,750	15,980	3,658	0	94	NA	-0.000003	-0.05
Dec	12/11 - 01/15	18,576	16,250	16,250	22,100	2,326	0	130	NA	0.000307	5.70
Jan	01/15 - 02/13	11,808	16,250	11,808	22,100	0	0	130	NA	0.000307	3.63
Feb	02/13 - 03/12	20,448	18,000	18,000	24,480	2,448	0	144	NA	0.000307	6.28
Mar	03/12 - 04/13	25,344	16,250	16,250	22,100	9,094	0	130	NA	0.000307	7.78
Apr	04/13 - 05/13	18,864	16,250	16,250	22,100	2,614	0	130	NA	0.000307	5.79
May	05/13 - 06/12	42,912	19,750	19,750	26,860	23,162	0	158	NA	0.000307	13.17
Jun	06/12 - 07/13	29,088	16,250	16,250	22,100	12,838	0	130	NA	0.000307	8.93
Jul	07/13 - 08/11	29,952	18,000	18,000	24,480	11,952	0	144	NA	0.000307	9.20
Aug	08/11 - 09/10	29,664	16,250	16,250	22,100	13,414	0	130	NA	0.000307	9.11
Sep	09/10 - 10/09	23,760	16,250	16,250	22,100	7,510	0	130	NA	0.000307	7.29
Oct	10/09 - 11/09	24,048	18,000	18,000	24,480	6,048	0	144	NA	0.000307	7.38
Totals		289,872	199,250	194,808	270,980	95,064	0	1,594			84.21
Average									NA		

Month	Billing Dates	Fuel Cost Factor ($/kwh)	Fuel Cost Charge ($)	Facilities Charge ($)	Demand Charge ($)	Energy Charge ($)	Sub-Total ($)	Fuel Refund ($)	Late Charge ($)	Total cal'c Bill ($)	Actual Bill ($)
Nov	11/11 - 12/11	0.019924	306.99	29.25	285.60	747.79	1,369.58			1,369.58	1,369.58
Dec	12/11 - 01/15	0.019924	370.11	29.25	408.00	943.22	1,756.28	280.78		1,475.50	1,475.50
Jan	01/15 - 02/13	0.019924	235.26	29.25	408.00	629.14	1,305.28		44.27	1,349.55	1,349.55
Feb	02/13 - 03/12	0.019924	407.41	29.25	455.60	1,040.52	1,939.06			1,939.06	1,939.06
Mar	03/12 - 04/13	0.019924	504.95	29.25	408.00	1,168.46	2,118.44			2,118.44	2,118.44
Apr	04/13 - 05/13	0.019924	375.85	29.25	408.00	1,012.22	1,831.11			1,831.11	1,831.11
May	05/13 - 06/12	0.019924	854.98	29.25	503.20	1,895.31	3,295.92			3,295.92	3,295.91
Jun	06/12 - 07/13	0.018869	548.86	29.25	408.00	1,352.46	2,347.50			2,347.50	2,347.50
Jul	07/13 - 08/11	0.018869	565.16	29.25	455.60	1,422.62	2,481.83	242.46		2,239.37	2,239.37
Aug	08/11 - 09/10	0.018869	559.73	29.25	408.00	1,371.63	2,377.72			2,377.72	2,377.72
Sep	09/10 - 10/09	0.019924	473.39	29.25	408.00	1,175.15	2,093.09			2,093.09	2,093.08
Oct	10/09 - 11/09	0.019924	479.13	29.25	455.60	1,160.33	2,131.69			2,131.69	2,131.69
Totals			5,681.83	351.00	5,011.60	13,918.85	25,047.50	523.24	44.27	24,568.53	24,568.51

Figure 8: Electrical Energy Consumption

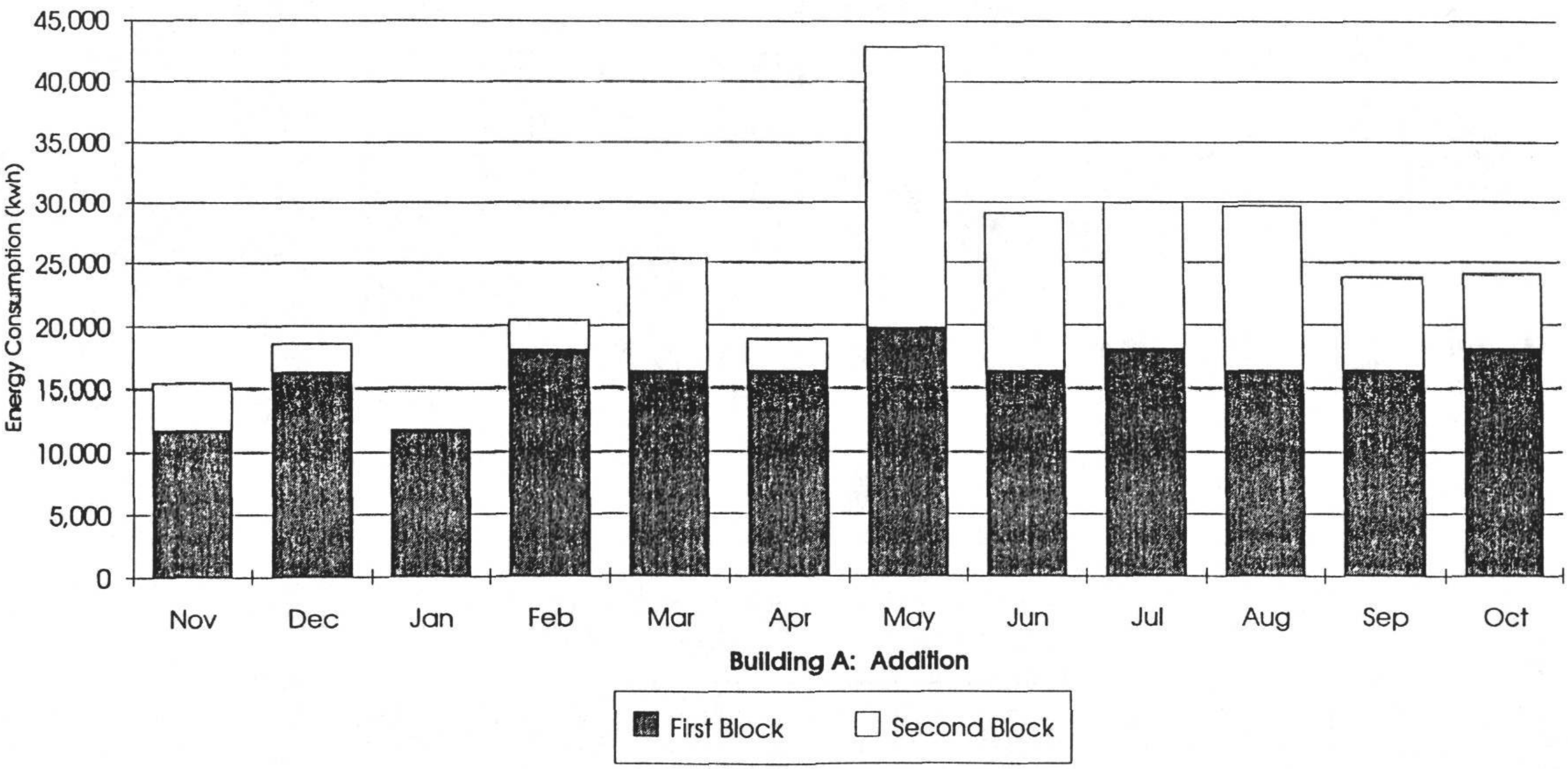


Figure 9: Electrical Demand

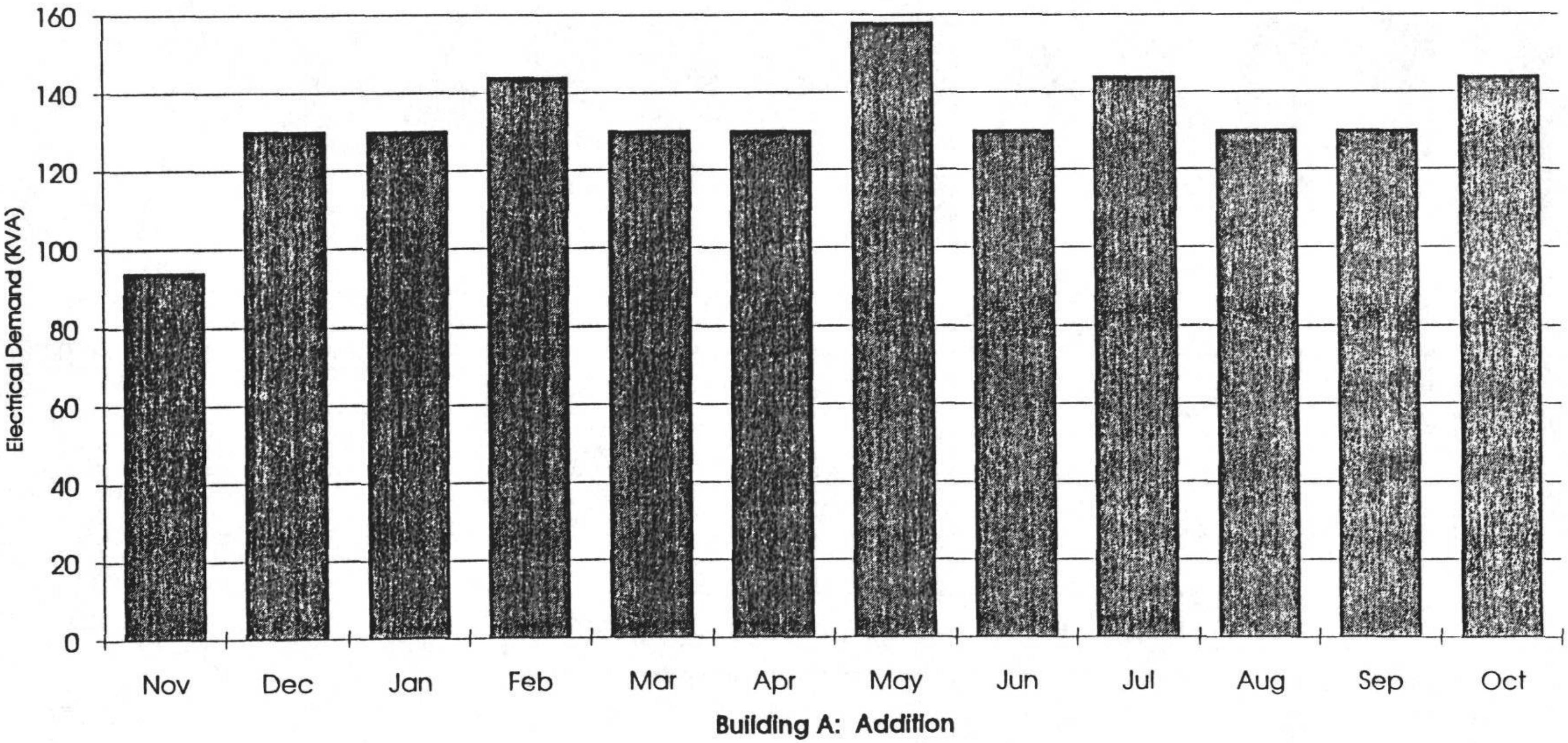


Figure 10: Electrical Energy Cost

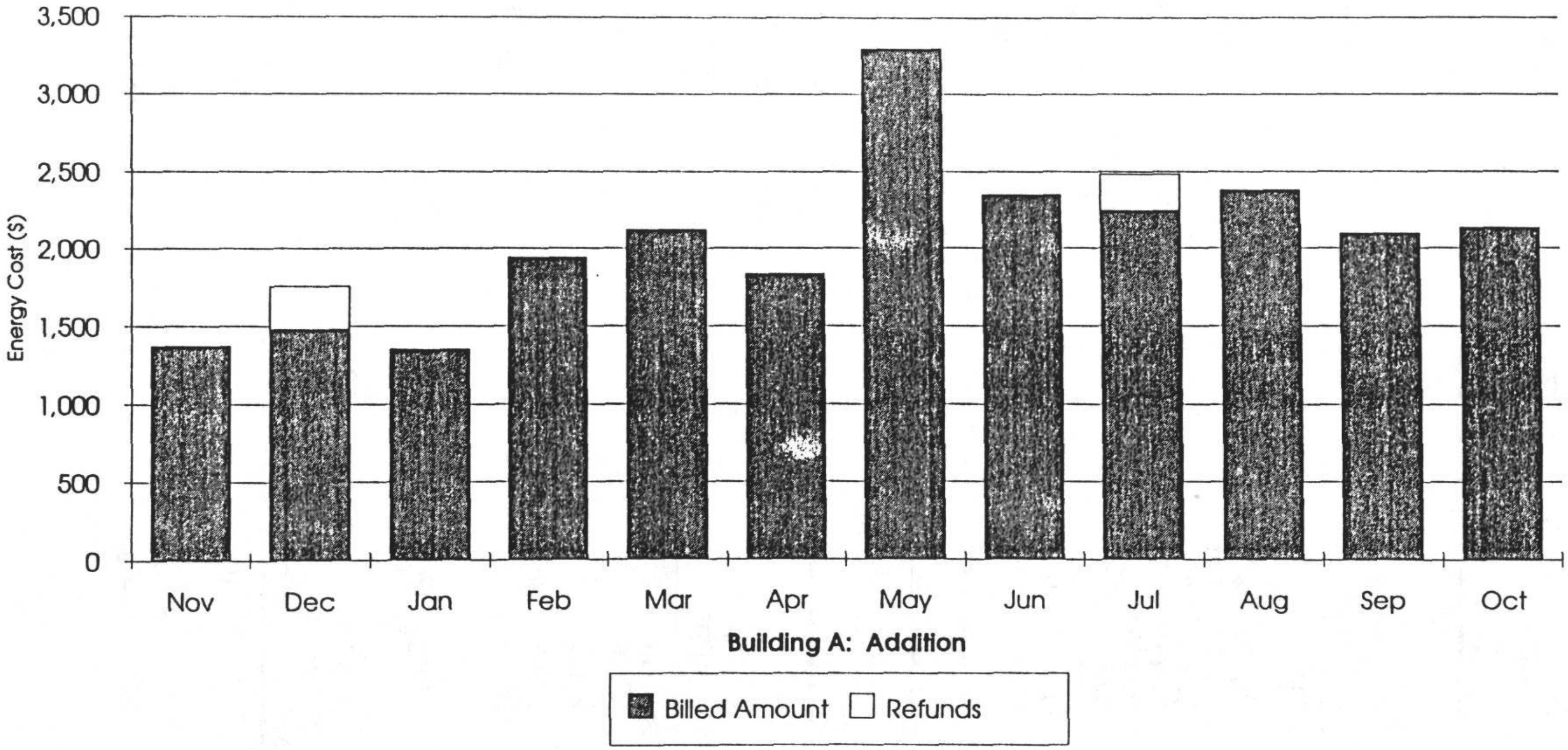


Table 6: Summary of Gas Consumption and Cost

BUILDING B

Month	Billing Dates	Gas Consumption (MCF)	Base Amount Cost ($)	Gas Consumption Cost ($)	Sales Tax ($)	Amount Billed ($)
Nov	11/13 - 12/16	103.9	369.70	72.31	36.47	478.48
Dec	12/16 - 01/17	103.1	366.98	71.76	36.20	474.94
Jan	01/17 - 02/14	113.7	402.89	81.92	40.00	524.81
Feb	02/14 - 03/16	118.2	418.13	85.16	41.52	544.81
Mar	03/16 - 04/15	100.8	359.19	72.63	35.63	467.45
Apr	04/15 - 05/15	91.8	328.72	66.14	32.58	427.44
May	05/15 - 06/16	98.4	351.07	70.90	34.81	456.78
Jun	06/16 - 07/16	91.5	327.70	65.93	32.47	426.10
Jul	07/16 - 08/17	96.0	342.94	46.92	32.16	422.02
Aug	08/17 - 09/16	93.4	334.14	45.64	31.33	411.11
Sep	09/16 - 10/16	90.7	324.98	44.33	30.47	399.78
Oct	10/16 - 11/16	97.9	349.38	47.84	32.77	429.99
Totals		1,199.4	4,275.82	771.48	416.41	5,463.71

BUILDING A

Month	Billing Dates	Gas Consumption (MCF)	Base Amount Cost ($)	Gas Consumption Cost ($)	Sales Tax ($)	Amount Billed ($)
Nov	11/13 - 12/16	280.0	699.38	612.69	108.25	1420.32
Dec	12/16 - 01/17	183.0	569.89	233.63	66.29	869.81
Jan	01/17 - 02/14	153.0	529.84	119.85	53.60	703.29
Feb	02/14 - 03/16	141.0	495.35	101.59	49.25	646.19
Mar	03/16 - 04/15	88.0	315.85	63.40	31.29	410.54
Apr	04/15 - 05/15	79.0	285.36	56.92	28.24	370.52
May	05/15 - 06/16	5.0	33.37	3.60	3.05	40.02
Jun	06/16 - 07/16	5.0	33.37	3.60	3.05	40.02
Jul	07/16 - 08/17	4.0	29.93	1.95	2.63	34.51
Aug	08/17 - 09/16	4.0	29.93	1.95	2.63	34.51
Sep	09/16 - 10/16	40.0	153.27	19.55	14.26	187.08
Oct	10/16 - 11/16	40.0	153.27	19.55	14.26	187.08
Totals		1,022.0	3,328.81	1,238.28	376.80	4,943.89

Meter 1: Account Number 41263036031, Entex Rate Schedule 4882
Meter 2: Account Number 41263030092, Entex Rate Schedule 4884

Figure 11: Natural Gas Consumption

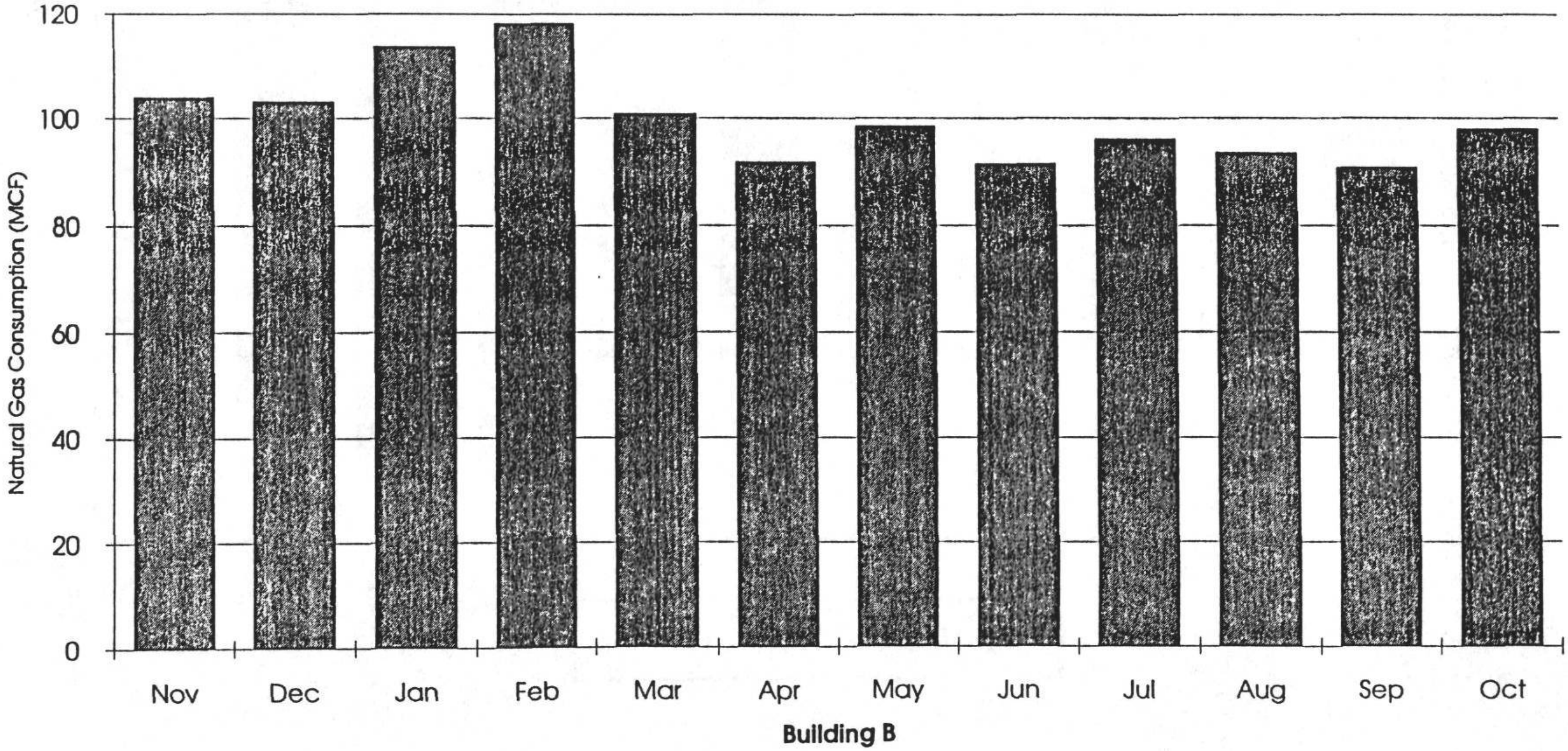


Figure 12: Natural Gas Cost

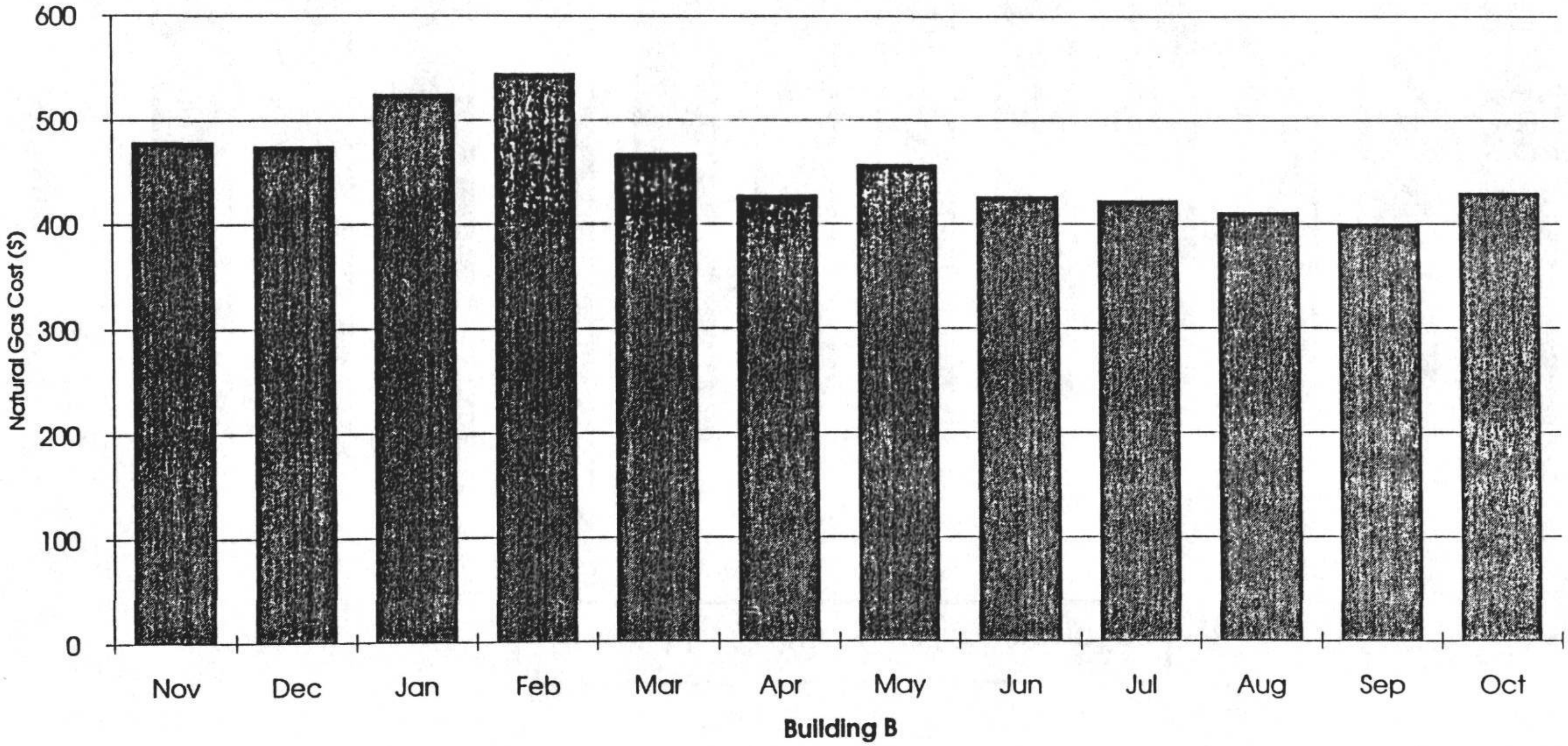


Figure 13: Natural Gas Consumption

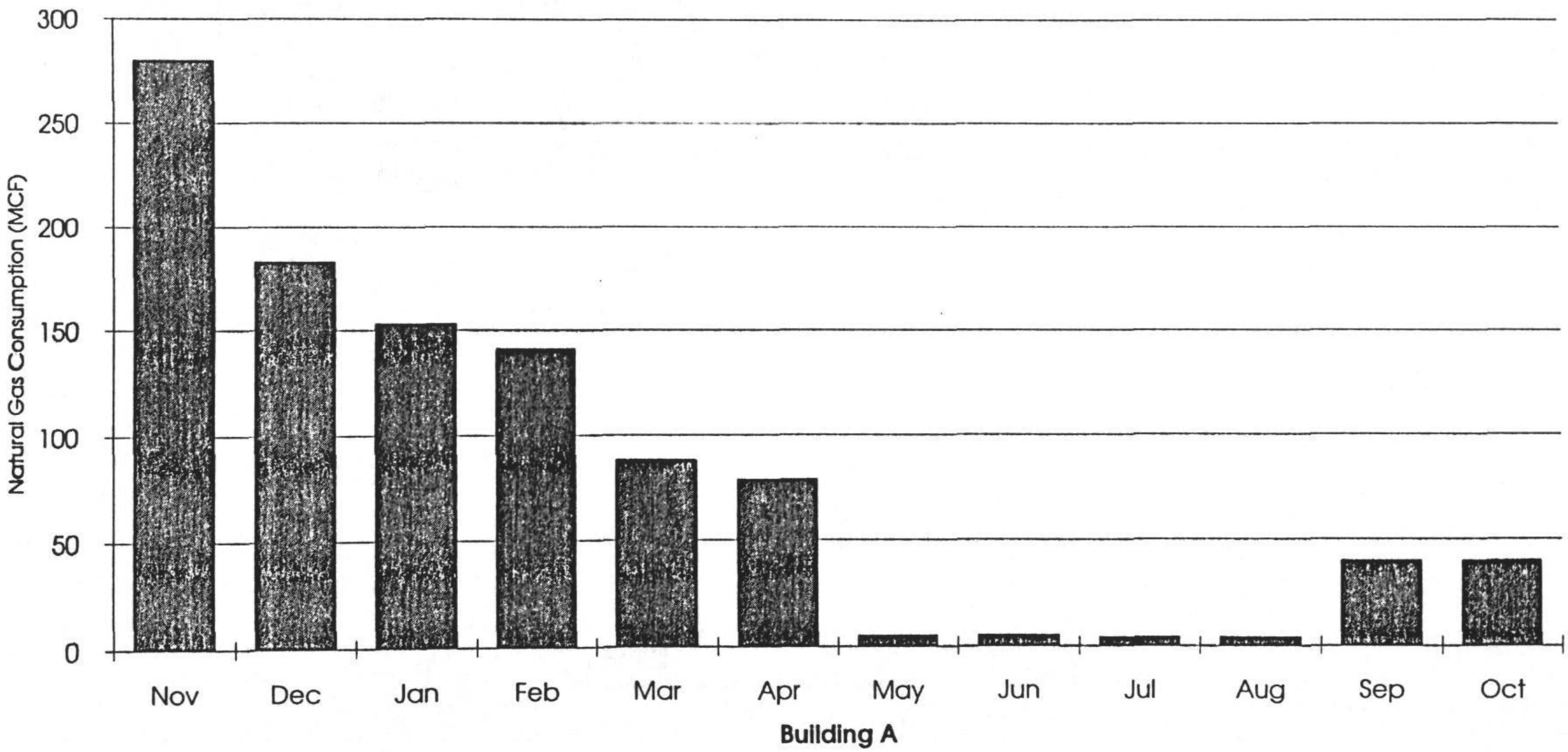
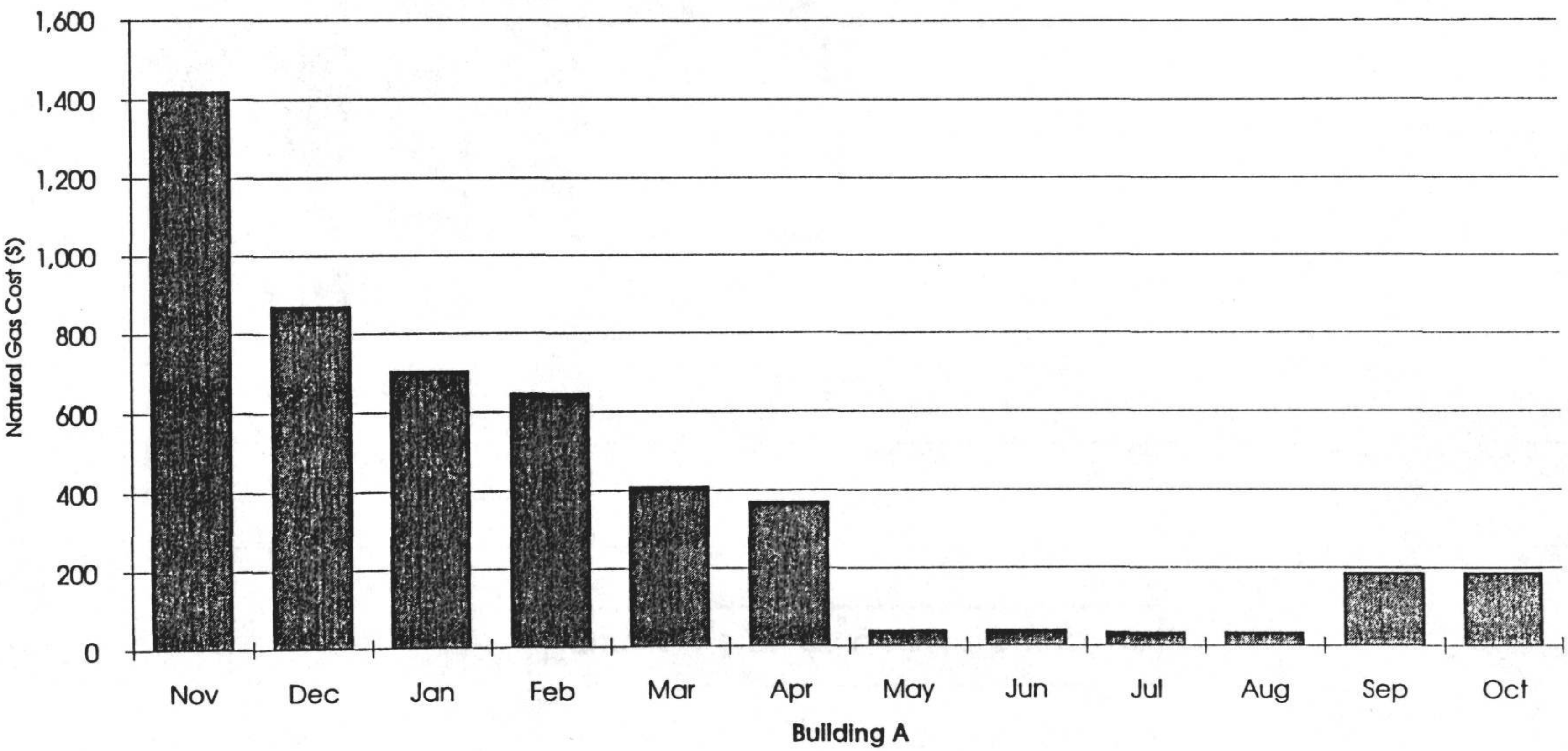


Figure 14: Natural Gas Cost



AVOIDED COST OF ELECTRICAL CONSUMPTION

The avoided cost of electrical energy consumption is composed of an energy charge, a fuel charge, Power Cost Recovery Factor (PCRF), and fuel refunds.

Energy Charge

The energy charge is the basic cost of energy used by the plant and is charged on a kilowatt-hour (kwh) basis. For the MGS rate schedule the energy usage is broken into three blocks. The first block contains 125 kwh for every KVA of demand, the second block contains 170 kwh for every KVA of demand, and the third block contains the remaining energy usage. The charges for the first block is $0.056937/kwh for the billing months of May through October and $0.053281 for the billing months of November through April. The second and third blocks are $0.033279/kwh and $0.007313/kwh, respectively for all billing months in the year. The avoided cost of energy usage will be calculated for each meter.

Meter 994636 (Building B)

The reviewed utility data indicates that the energy usage is in the second block for one month and in the third block for the remaining eleven months. Therefore the avoided cost of energy will be taken as the weighted average energy charge for the second and third blocks. The energy charge is:

= {[Third block energy charge ($/kwh) × N° of months in the third block (mo/yr)]

+ [Second block energy charge ($/kwh) × N° of months in the second block (mo/yr)]} ÷ 12 months

= {[$0.007313/kwh × 11 mo/yr] + [$0.033279/kwh × 1 mo/yr]} ÷ 12 months

= $0.009477/kwh

Meter W62181917 (Building A, original area)

The reviewed utility data indicates that the energy usage is in the second block for seven months and in the third block for five months. Therefore the avoided cost of energy will be taken as the weighted average energy charge for the second and third blocks. The energy charge is:

= {[Third block energy charge ($/kwh) × N° of months in the third block (mo/yr)] + [Second block energy charge ($/kwh) × N° of months in the second block (mo/yr)]} ÷ 12 months

= {[$0.007313/kwh × 5 mo/yr] + [$0.033279/kwh × 7 mo/yr]} ÷ 12 months

= $0.022460/kwh

Meter S50954244 (Building A, addition)

The reviewed utility data indicates that the energy usage is in the first block for one month (occurring during a winter billing period) and in the second block for the remaining eleven months. Therefore the avoided cost of energy will be taken as the weighted average energy charge for the first block (using the winter billing rate) and second block. The energy charge is:

= {[Second block energy charge ($/kwh) × N° of months in the second block (mo/yr)] + [First block energy charge ($/kwh) × N° of months in the first block (mo/yr)]} ÷ 12 months

= {[\$0.033279/kwh × 11 mo/yr] + [\$0.053281/kwh × 1 mo/yr]} ÷ 12 months

= \$0.034946/kwh

Fuel Charge

The conventional fuel charge for the MGS rate schedules is \$0.019924/kwh. However, during the period of June 1992 to August 1992, the fuel charge for the MGS rate schedule was \$0.018869/kwh. Since this rate only lasted for three months, the conventional rate will be used in our calculation

= \$0.019924/kwh

Power Cost Recovery Factor

The PCRF is used by the utility to pass through purchased electricity charges or refunds. The first month in Tables 3-5 had a credit of \$0.000003/kwh. The remaining eleven months had a charge of \$0.000307/kwh. However, a new PCRF charge of \$0.000523/kwh went into effect as of January, 1993, and we will use this new rate in our calculation:

= \$0.000523/kwh

Fuel Refund

Fuel refunds are given twice a year, once in July and once in December, to account for variations in the price of the fuel purchased by the utility for generating electricity. The average fuel refund for this facility is:

= Sum of refunds (\$/yr) ÷ Sum energy usage (kwh/yr)

= (\$3,691.21 + \$3,153.13 + \$523.24)/yr ÷ (2,184,169 kwh 1,725,696 kwh

+ 289,872 kwh)/yr

= $0.0017/kwh

Avoided Cost of Electrical Consumption

= Energy charge + Fuel charge + PCRF - Fuel refunds

Meter 994636 (Building B)

= $0.009477/kwh + $0.019924/kwh + $0.000523/kwh - $0.0017/kwh

= $0.028/kwh

Meter W62181917 (Building A, original area)

= $0.022460/kwh + $0.019924/kwh + $0.000523/kwh - $0.0017/kwh

= $0.041/kwh

Meter S50954244 (Building A, addition)

= $0.034946/kwh + $0.019924/kwh + $0.000523/kwh - $0.0017/kwh

= $0.054/kwh

These values will be used to determine the electrical energy savings in this report.

AVOIDED COST OF ELECTRICAL DEMAND

The demand cost is a charge paid for the rate at which electrical energy is consumed and is measured in Kilovolt-Amperes. The avoided cost of demand consists of the base charge plus a block expansion penalty.

Base Charge

For the MGS rate schedule, the applicable demand charge for all billing demand in excess of 10 KVA per month is:

= $3.40/KVA•mo

Block Expansion Penalty

The first and second energy consumption blocks are flexible monthly, and are determined to be 125 kwh and 170 kwh per every KVA•mo of billed primary demand, respectively. Any addition kwh used are charged at the third block rate. The flexible block size amounts to an additional demand based charge which will be called a block expansion penalty. If demand is reduced, the size of the first and second blocks will decrease. Since actual consumption does not change, this will cause more of the consumption to be shifted to the lowest cost block. This amounts to additional savings due to the demand reduction only. The avoided cost of energy which is associated with this demand charge is the sum of the differences in the block energy charges, times the block expansion multipliers.

First block average cost

= (Summer billing rate + Winter billing rate) ÷ 2

= ($0.056937/kwh + $0.053281/kwh) ÷ 2

= \$0.055109/kwh

Meter 994636

This meter has energy charged in the second block for one month and the third block for eleven months.

= {[(Price difference between first and second block) × First block expansion multiplier × N° of months] + [(Price difference between first and third block × First block expansion multiplier) + (Price difference between second and third block × Second block expansion multiplier)] × N° of months} ÷ 12 months

= {[(\$0.055109/kwh - \$0.033279/kwh) × 125 kwh/KVA●mo × 1 month] + [(\$0.055109 - \$0.007313/kwh) × 125 kwh/KVA●mo + (\$0.033279/kwh - \$0.007313/kwh) × 170 kwh/KVA●mo] × 11 months} ÷ 12 months

= \$9.75/KVA●mo

Meter W62181917

This meter has energy charged in the second block for seven months and the third block for five months.

= {[(Price difference between first and second block) × First block expansion multiplier × N° of months] + [(Price difference between first and third block × First block expansion multiplier) + (Price difference between second and third block × Second block expansion multiplier)] × N° of months} ÷ 12 months

= {[(\$0.055109/kwh - \$0.033279/kwh) × 125 kwh/KVA●mo × 7 months] + [(\$0.055109 - \$0.007313/kwh) × 125 kwh/KVA●mo + (\$0.033279/kwh - \$0.007313/kwh) × 170 kwh/KVA●mo] × 5 months} ÷ 12 months

= $5.92/KVA•mo

Meter S50954244

This meter has energy charged in the first block for one month and the second block for eleven months.

= [(Price difference between first and second block) × First block expansion multiplier × N° of months] ÷ 12 months

= [($0.055109/kwh - $0.033279/kwh) × 125 kwh/KVA•mo × 11 months] ÷ 12 months

= $2.50/KVA•mo

Avoided Cost of Electrical Demand

The total avoided cost of electrical demand is

= [Base demand charge ($/KVA•mo) + Block expansion penalty ($/KVA•mo)]

Meter 994636 (Building B)

= $3.40/KVA•mo + $9.75/KVA•mo

= $13.15/KVA•mo

Meter W62181917 (Building A, original area)

= $3.40/KVA•mo + $5.92/KVA•mo

= $9.32/KVA•mo

Meter S50954244 (Building A, addition)

= $3.40/KVA•mo + $2.50/KVA•mo

= $5.90/KVA•mo

AVOIDED COST OF NATURAL GAS

The natural gas for this facility is supplied by ENTEX via two meters. The charge for natural gas is on the basis of hundred cubic feet (CCF) consumed for meter 1 and thousand cubic feet (MCF) consumed for meter 2. The average avoided cost of natural gas is calculated based on MCF and is:

= Total gas costs ($) ÷ Total gas consumption (MCF)

= $10,407.60 ÷ 2,221.4 MCF

= $4.69/MCF.

LOAD FACTOR ANALYSIS

Load Factors

The electrical load factor (ELF) and the production load factor (PLF) for all three meters are shown in Figures 15-17. This data is extracted from the electrical energy and demand tabulated in Tables 3-5.

Electrical Load Factor

In an ideal case, a load factor of 1.0 is defined as the facility using the monthly peak demand 24 hours per day throughout the entire monthly billing period. The electrical load factor is defined as:

$$ELF = \frac{\textit{Energy Consumption during billing period}}{\textit{Monthly Demand} \times PF \times \textit{Billing Days} \times 24\ hrs/day}$$

The nominal single shift plant electrical load factor should be about 0.20 - 0.25 for a plant operating five days/week at full capacity. For plants with nominal two shift operation, it should be about 0.45 - 0.60, while the nominal three shift operation should have an electrical load factor of about 0.70 - 0.80.

The electrical load factors for this facility ranged between 0.5 to 0.7 for Building B, 0.3 to 0.5 for Building A (original building area), and 0.1 to 0.35 for Building A (addition) for the reported 12 month period. The most likely reason for electrical load factors in excess of the nominal values for Building B is equipment (such as air conditioners) operating after hours. Power factor data was not available for the two meters in Building A and was assumed to be one for our electrical load factor calculation.

Figure 15: Load Factors

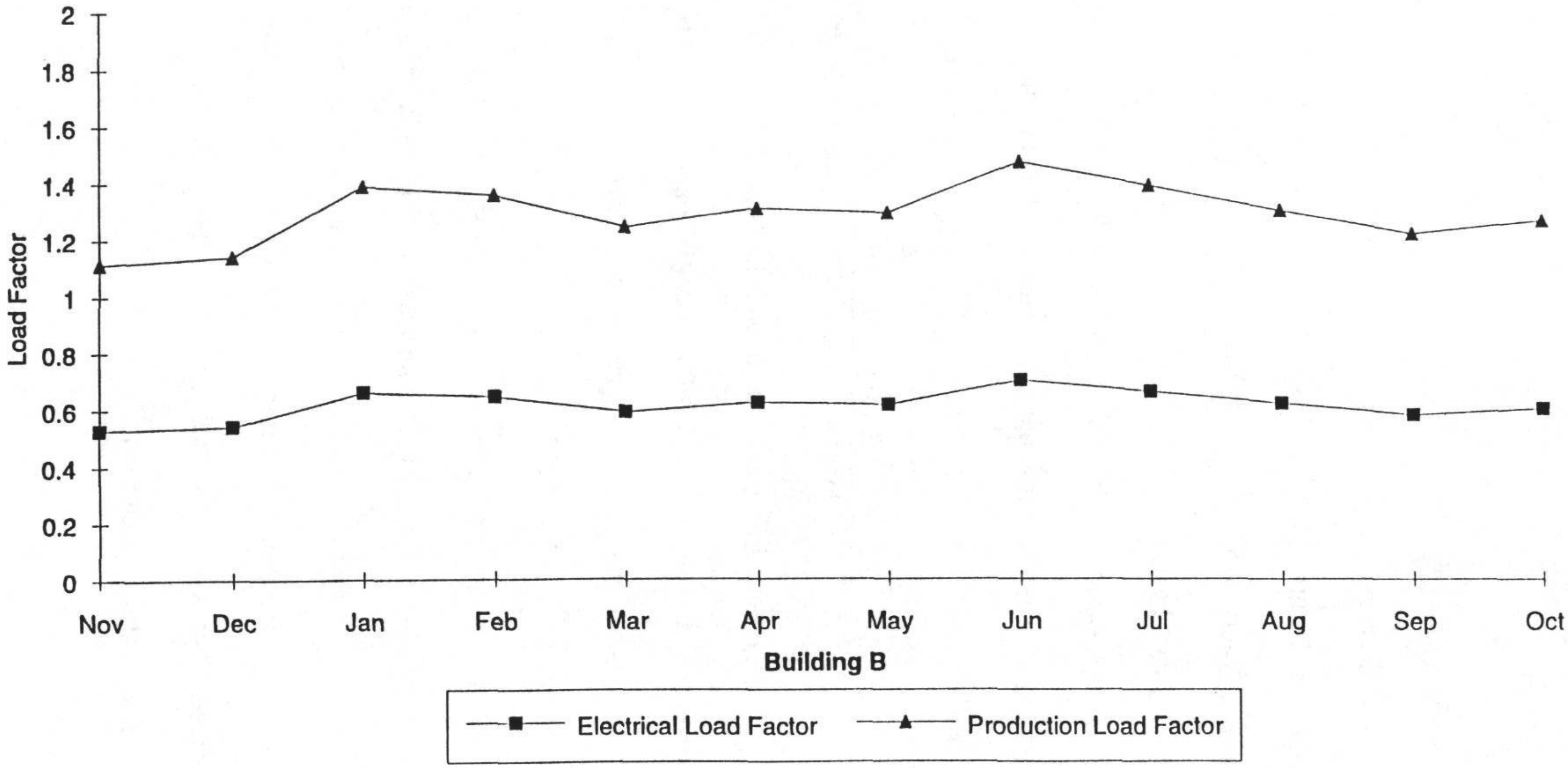


Figure 16: Load Factors

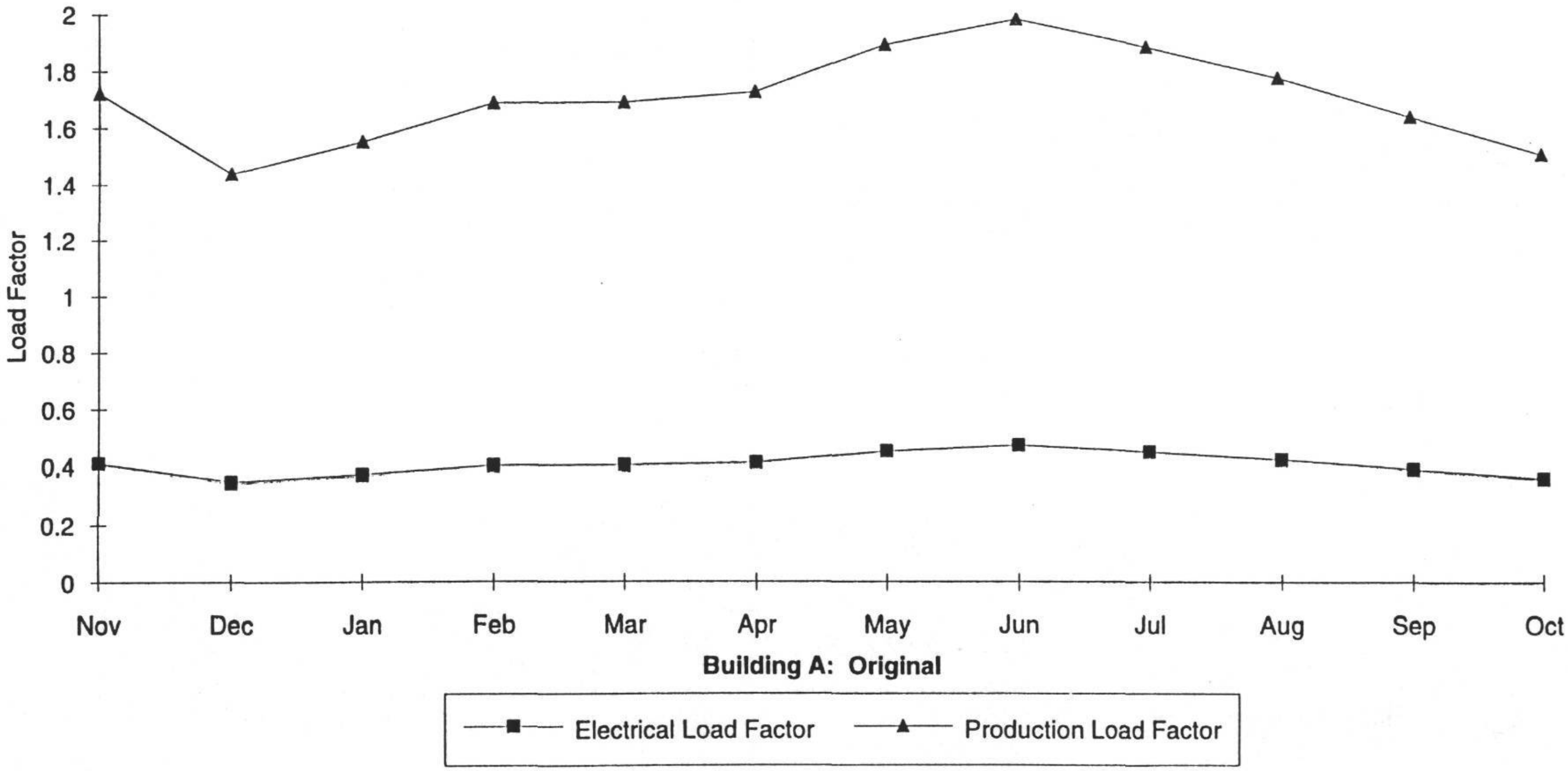
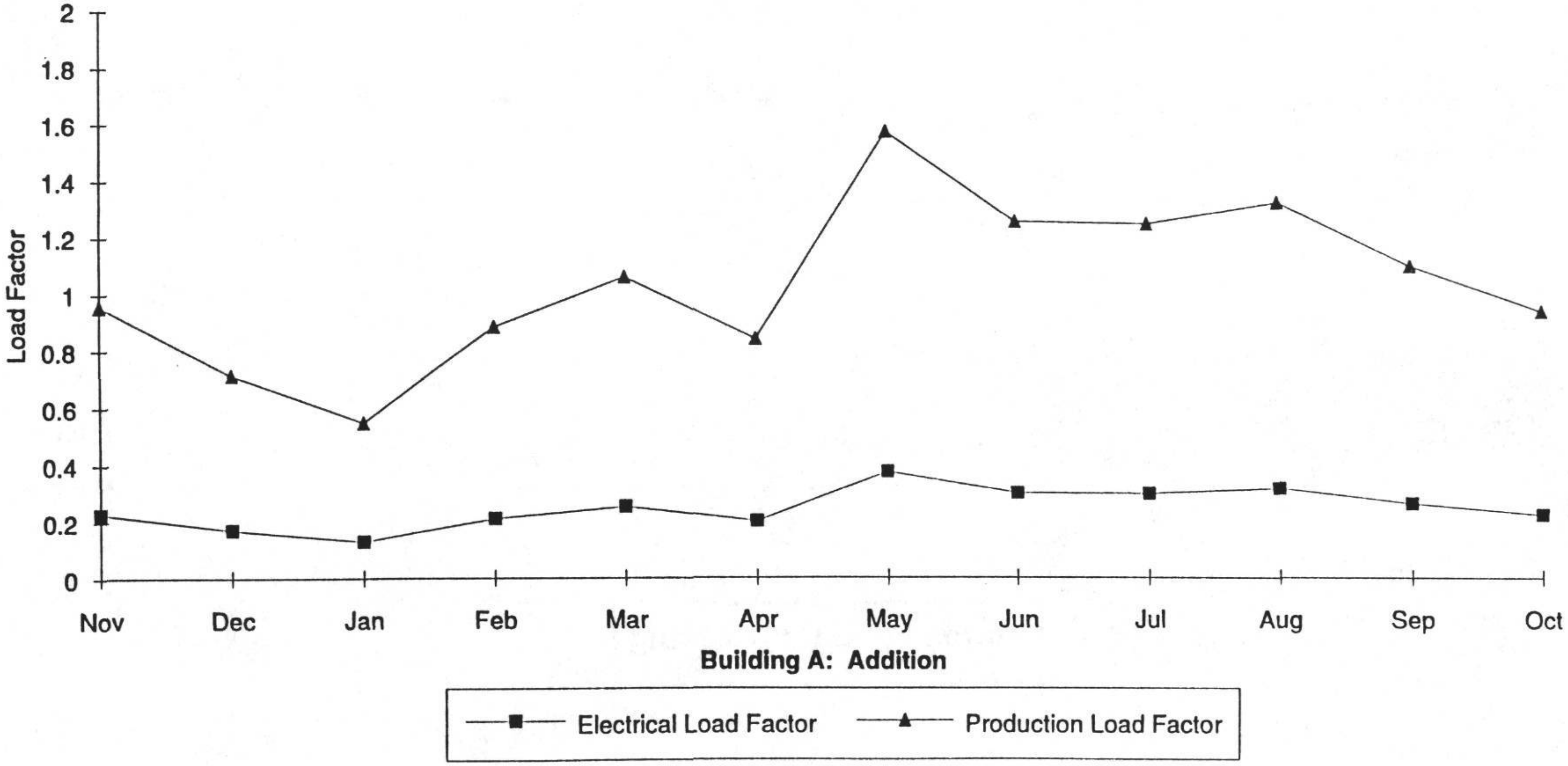


Figure 17: Load Factors



This assumption of a unity power factor generally will lower the electrical load factor when compared to an electrical load factor calculated with actual power factor data.

Production Load Factor

The production load factor is defined as:

$$P\ L\ F = \frac{\textit{Energy Consumption during billing period}}{\textit{Monthly Demand} \times \textit{PF} \times \textit{Production hours per billing period}}$$

A production load factor over one indicates that equipment may be running during non-working (non-production) hours. The production load factors for this facility ranged between 1.10 to 1.50 for Building B, 1.45 to 2.05 for Building A (original building area) and 0.55 to 1.06 for Building A (addition) for the reported 12 month period.

The most likely reason for production load factors in excess of one for your plant is the equipment which remains on during non-production hours.

ENERGY CONSERVATION OPPORTUNITIES

ECO #1

METER CONSOLIDATION WITH RATE SCHEDULES CHANGE

Recommended Action

Combine the three existing electrical meters into one service meter. Change current HL&P electrical rate structure from Miscellaneous General Service to Large General Service.

Summary of Estimated Savings and Implementation Costs

There will be no electrical energy and no demand savings associated with this ECO. The anticipated annual cost savings are $12,900. The implementation costs are $40,000, yeilding a simple payback period of 3.1 years.

Note: The success of this ECO is very sensitive to factors such as fuel refunds and PCRFs. We recommend that our savings estimate be confirmed by HL&P, and that a quotation be obtained from a contractor before further action is taken.

Current Operations and Observations

Presently electrical service is provided by HL&P through three meters, 994636, W62181917, and S50954244. The rate structure for these three meters is under the Miscellaneous General Service. The total energy bill for 1991-1992 was $289,087.11 for all three meters. The maximum demand for the combination of all three meters was 1298 KVA while the minimum demand was 917 KVA.

It is recommended that the three meters be combined into one service and the rate structure be switched to HL&P's Large General Service (LGS).

<u>Calculations</u>

The LGS rate structure was used to predict annual costs for the combined service. A copy of this rate structure may be found in Appendix B of this report. The PCRF for the LGS schedule is $0.000449/kwh. An averaged fuel refund, based on 1992 data, of $0.003156/kwh was used.[1]

Tables 1.1 through 1.3 show predicted total costs, based on the November, 1991 to October, 1992 consumption in Tables 3-5, for the three separate meters under the MGS schedule using the most recent rates. Table 1.4 shows the predicted costs for combined service under the LGS rate structure, and using the PCRF and fuel refund referenced above.

<u>Total Cost Savings ($/yr)</u>

= Predicted MGS Bill - Predicted LGS Bill

= $289,834.80/yr - $276,885.10/yr

= $12,949.70

<u>Implementation Costs ($)</u>

A new transformer will be provided by HL&P. The facility electrical load will require the new transformer to be pad mounted. The plant owner will be responsible only for the cost and installation of the underground conduit from the pad mount to the service ports.

---

[1] From LGS data in EADC report 93-171.

Table 1.1: Summary of Electrical Consumption, Demand, and Cost under current Rate Schedule

Building B

Meter Number **994636**

Month	Billing Dates	Energy Consumed (kwh)	Size of Block 1 (kwh)	Consumption In Block 1 (kwh)	Size of Block 2 (kwh)	Consumption In Block 2 (kwh)	Consumption In Block 3 (kwh)	Demand (KVA)	Power Factor	PCRF Charge ($/kwh)	PCRF Cost ($)
Nov	11/11 - 12/10	142,400	64,500	64,500	87,720	77,900	0	516	0.75	0.000523	74.48
Dec	12/10 - 01/10	122,400	48,000	48,000	65,280	65,280	9,120	384	0.79	0.000523	64.02
Jan	01/10 - 02/11	155,680	54,750	54,750	74,460	74,460	26,470	438	0.70	0.000523	81.42
Feb	02/11 - 03/11	167,200	64,500	64,500	87,720	87,720	14,980	516	0.72	0.000523	87.45
Mar	03/11 - 04/09	160,480	60,000	60,000	81,600	81,600	18,880	480	0.81	0.000523	83.93
Apr	04/09 - 05/11	183,040	63,625	63,625	86,530	86,530	32,885	509	0.75	0.000523	95.73
May	05/11 - 06/10	185,280	70,500	70,500	95,880	95,880	18,900	564	0.74	0.000523	96.90
Jun	06/10 - 07/13	275,040	81,250	81,250	110,500	110,500	83,290	650	0.76	0.000523	143.85
Jul	07/13 - 08/12	227,440	75,375	75,375	102,510	102,510	49,555	603	0.79	0.000523	118.95
Aug	08/12 - 09/10	201,200	72,750	72,750	98,940	98,940	29,510	582	0.80	0.000523	105.23
Sep	09/10 - 10/09	175,440	70,375	70,375	95,710	95,710	9,355	563	0.77	0.000523	91.76
Oct	10/09 - 11/10	188,560	60,500	60,500	82,280	82,280	45,780	484	0.84	0.000523	98.62
Totals		2,184,160	786,125	786,125	1,069,130	1,059,310	338,725	6,289			1,142.32
Average									0.77		

Month	Billing Dates	Fuel Cost Factor ($/kwh)	Fuel Cost Charge ($)	Facilities Charge ($)	Demand Charge ($)	Energy Charge ($)	Sub-Total ($)	Fuel Refund ($)	Late Charge ($)	Total cal'c Bill ($)
Nov	11/11 - 12/10	0.019924	2,837.18	29.25	1,720.40	6,029.06	10,690.36			10,690.36
Dec	12/10 - 01/10	0.019924	2,438.70	29.25	1,271.60	4,796.64	8,600.20	1,850.08		6,750.12
Jan	01/10 - 02/11	0.019924	3,101.77	29.25	1,455.20	5,588.66	10,256.30			10,256.30
Feb	02/11 - 03/11	0.019924	3,331.29	29.25	1,720.40	6,465.41	11,633.80			11,633.80
Mar	03/11 - 04/09	0.019924	3,197.40	29.25	1,598.00	6,050.50	10,959.08			10,959.08
Apr	04/09 - 05/11	0.019924	3,646.89	29.25	1,696.60	6,742.74	12,211.21			12,211.21
May	05/11 - 06/10	0.019924	3,691.52	29.25	1,883.60	7,343.06	13,044.33			13,044.33
Jun	06/10 - 07/13	0.018869	5,189.73	29.25	2,176.00	8,912.56	16,451.39			16,451.39
Jul	07/13 - 08/12	0.018869	4,291.57	29.25	2,016.20	8,065.45	14,521.42	1,841.13		12,680.29
Aug	08/12 - 09/10	0.018869	3,796.44	29.25	1,944.80	7,650.60	13,526.32			13,526.32
Sep	09/10 - 10/09	0.019924	3,495.47	29.25	1,880.20	7,260.49	12,757.16			12,757.16
Oct	10/09 - 11/10	0.019924	3,756.87	29.25	1,611.60	6,296.49	11,792.82			11,792.82
Totals			42,774.82	351.00	20,974.60	81,201.65	146,444.38	3,691.21	0.00	142,753.17

Table 1.2: Summary of Electrical Consumption, Demand, and Cost under current Rate Schedule

Building A: Addition

Meter Number
S50954244

Month	Billing Dates	Energy Consumed (kwh)	Size of Block 1 (kwh)	Consumption In Block 1 (kwh)	Size of Block 2 (kwh)	Consumption In Block 2 (kwh)	Consumptior In Block 3 (kwh)	Demand (KVA)	Power Factor	PCRF Charge ($/kwh)	PCRF Cost ($)
Nov	11/11 - 12/11	15,408	11,750	11,750	15,980	3,658	0	94	NA	0.000523	8.06
Dec	12/11 - 01/15	18,576	16,250	16,250	22,100	2,326	0	130	NA	0.000523	9.72
Jan	01/15 - 02/13	11,808	16,250	11,808	22,100	0	0	130	NA	0.000523	6.18
Feb	02/13 - 03/12	20,448	18,000	18,000	24,480	2,448	0	144	NA	0.000523	10.69
Mar	03/12 - 04/13	25,344	16,250	16,250	22,100	9,094	0	130	NA	0.000523	13.25
Apr	04/13 - 05/13	18,864	16,250	16,250	22,100	2,614	0	130	NA	0.000523	9.87
May	05/13 - 06/12	42,912	19,750	19,750	26,860	23,162	0	158	NA	0.000523	22.44
Jun	06/12 - 07/13	29,088	16,250	16,250	22,100	12,838	0	130	NA	0.000523	15.21
Jul	07/13 - 08/11	29,952	18,000	18,000	24,480	11,952	0	144	NA	0.000523	15.66
Aug	08/11 - 09/10	29,664	16,250	16,250	22,100	13,414	0	130	NA	0.000523	15.51
Sep	09/10 - 10/09	23,760	16,250	16,250	22,100	7,510	0	130	NA	0.000523	12.43
Oct	10/09 - 11/09	24,048	18,000	18,000	24,480	6,048	0	144	NA	0.000523	12.58
Totals		289,872	199,250	194,808	270,980	95,064	0	1,594			151.60
Average									NA		

Month	Billing Dates	Fuel Cost Factor ($/kwh)	Fuel Cost Charge ($)	Facilities Charge ($)	Demand Charge ($)	Energy Charge ($)	Sub-Total ($)	Fuel Refund ($)	Late Charge ($)	Total cal'c Bill ($)
Nov	11/11 - 12/11	0.019924	306.99	29.25	285.60	747.79	1,377.68			1,377.68
Dec	12/11 - 01/15	0.019924	370.11	29.25	408.00	943.22	1,760.30	280.78		1,479.52
Jan	01/15 - 02/13	0.019924	235.26	29.25	408.00	629.14	1,307.83			1,307.83
Feb	02/13 - 03/12	0.019924	407.41	29.25	455.60	1,040.52	1,943.48			1,943.48
Mar	03/12 - 04/13	0.019924	504.95	29.25	408.00	1,168.46	2,123.91			2,123.91
Apr	04/13 - 05/13	0.019924	375.85	29.25	408.00	1,012.22	1,835.18			1,835.18
May	05/13 - 06/12	0.019924	854.98	29.25	503.20	1,895.31	3,305.19			3,305.19
Jun	06/12 - 07/13	0.018869	548.86	29.25	408.00	1,352.46	2,353.79			2,353.79
Jul	07/13 - 08/11	0.018869	565.16	29.25	455.60	1,422.62	2,488.30	242.46		2,245.84
Aug	08/11 - 09/10	0.018869	559.73	29.25	408.00	1,371.63	2,384.13			2,384.13
Sep	09/10 - 10/09	0.019924	473.39	29.25	408.00	1,175.15	2,098.22			2,098.22
Oct	10/09 - 11/09	0.019924	479.13	29.25	455.60	1,160.33	2,136.89			2,136.89
Totals			5,681.83	351.00	5,011.60	13,918.85	25,114.88	523.24	0.00	24,591.64

Table 1.3: Summary of Electrical Consumption, Demand, and Cost under current Rate Schedule

Building A: Original

Meter Number
W62181917

Month	Billing Dates	Energy Consumed (kwh)	Size of Block 1 (kwh)	Consumption in Block 1 (kwh)	Size of Block 2 (kwh)	Consumption in Block 2 (kwh)	Consumption in Block 3 (kwh)	Demand (KVA)	Power Factor	PCRF Charge ($/kwh)	PCRF Cost ($)
Nov	11/11 - 12/11	131,616	55,750	55,750	75,820	75,820	46	446	NA	0.000523	68.84
Dec	12/11 - 01/15	116,064	50,375	50,375	68,510	65,689	0	403	NA	0.000523	60.70
Jan	01/15 - 02/13	111,456	54,000	54,000	73,440	57,456	0	432	NA	0.000523	58.29
Feb	02/13 - 03/12	117,216	54,000	54,000	73,440	63,216	0	432	NA	0.000523	61.30
Mar	03/12 - 04/13	134,496	54,000	54,000	73,440	73,440	7,056	432	NA	0.000523	70.34
Apr	04/13 - 05/13	137,664	57,625	57,625	78,370	78,370	1,669	461	NA	0.000523	72.00
May	05/13 - 06/12	169,920	64,750	64,750	88,060	88,060	17,110	518	NA	0.000523	88.87
Jun	06/12 - 07/13	184,032	64,750	64,750	88,060	88,060	31,222	518	NA	0.000523	96.25
Jul	07/13 - 08/11	172,800	68,375	68,375	92,990	92,990	11,435	547	NA	0.000523	90.37
Aug	08/11 - 09/10	168,192	68,375	68,375	92,990	92,990	6,827	547	NA	0.000523	87.96
Sep	09/10 - 10/09	150,048	68,375	68,375	92,990	81,673	0	547	NA	0.000523	78.48
Oct	10/09 - 11/09	132,192	61,250	61,250	83,300	70,942	0	490	NA	0.000523	69.14
Totals		1,725,696	721,625	721,625	981,410	928,706	75,365	5,773			902.54
Average									NA		

Month	Billing Dates	Fuel Cost Factor ($/kwh)	Fuel Cost Charge ($)	Facilities Charge ($)	Demand Charge ($)	Energy Charge ($)	Sub-Total ($)	Fuel Refund ($)	Late Charge ($)	Total cal'c Bill ($)
Nov	11/11 - 12/11	0.019924	2,622.32	29.25	1,482.40	5,493.97	9,696.77			9,696.77
Dec	12/11 - 01/15	0.019924	2,312.46	29.25	1,336.20	4,870.09	8,608.71	1,754.31		6,854.40
Jan	01/15 - 02/13	0.019924	2,220.65	29.25	1,434.80	4,789.25	8,532.24			8,532.24
Feb	02/13 - 03/12	0.019924	2,335.41	29.25	1,434.80	4,980.94	8,841.70			8,841.70
Mar	03/12 - 04/13	0.019924	2,679.70	29.25	1,434.80	5,372.78	9,586.87			9,586.87
Apr	04/13 - 05/13	0.019924	2,742.82	29.25	1,533.40	5,901.28	10,278.74			10,278.74
May	05/13 - 06/12	0.019924	3,385.49	29.25	1,727.20	6,742.34	11,973.15			11,973.15
Jun	06/12 - 07/13	0.018869	3,472.50	29.25	1,727.20	6,845.55	12,170.74			12,170.74
Jul	07/13 - 08/11	0.018869	3,260.56	29.25	1,825.80	7,071.31	12,277.29	1,398.82		10,878.47
Aug	08/11 - 09/10	0.018869	3,173.61	29.25	1,825.80	7,037.61	12,154.24			12,154.24
Sep	09/10 - 10/09	0.019924	2,989.56	29.25	1,825.80	6,611.06	11,534.14			11,534.14
Oct	10/09 - 11/09	0.019924	2,633.79	29.25	1,632.00	5,624.34	9,988.52			9,988.52
Totals			33,828.87	351.00	19,220.20	71,340.52	125,643.12	3,153.13	0.00	122,489.99

Table 1.4: Predicted LGS Schedule with Demand equal to sum of each Meter's Demand

Month	Billing Dates	Energy Consumed (kwh)	Size of Block 1 (kwh)	Consumption In Block 1 (kwh)	onsumptic In Block 3 (kwh)	Demand (KVA)	Ratcheted Demand (KVA)	Power Factor	PCRF Charge ($/kwh)	PCRF Cost ($)
Nov	11/11 - 12/10	289,424	325,474	289,424	0	1,056	1,103	0.75	0.000449	129.95
Dec	12/10 - 01/10	257,040	325,474	257,040	0	917	1,103	0.79	0.000449	115.41
Jan	01/10 - 02/11	278,944	325,474	278,944	0	1,000	1,103	0.70	0.000449	125.25
Feb	02/11 - 03/11	304,864	325,474	304,864	0	1,092	1,103	0.72	0.000449	136.88
Mar	03/11 - 04/09	320,320	325,474	320,320	0	1,042	1,103	0.81	0.000449	143.82
Apr	04/09 - 05/11	339,568	325,474	325,474	14,095	1,100	1,103	0.75	0.000449	152.47
May	05/11 - 06/10	398,112	365,800	365,800	32,312	1,240	1,240	0.74	0.000449	178.75
Jun	06/10 - 07/13	488,160	382,910	382,910	105,250	1,298	1,298	0.76	0.000449	219.18
Jul	07/13 - 08/12	430,192	381,730	381,730	48,462	1,294	1,294	0.79	0.000449	193.16
Aug	08/12 - 09/10	399,056	371,405	371,405	27,651	1,259	1,259	0.80	0.000449	179.18
Sep	09/10 - 10/09	349,248	365,800	349,248	0	1,240	1,240	0.77	0.000449	156.81
Oct	10/09 - 11/10	344,800	329,810	329,810	14,990	1,118	1,118	0.84	0.000449	154.82
Totals		4,199,728	4,150,296	3,956,969	242,760	13,656	14,069			1,885.68
Average								0.77		

Month	Billing Dates	Fuel Cost Factor ($/kwh)	Fuel Cost Charge ($)	Facilities Charge ($)	Demand Charge ($)	Energy Charge ($)	Sub-Total ($)	Fuel Refund ($)	Late Charge ($)	Total cal'c Bill ($)
Nov	11/11 - 12/10	0.019924	5,766.48	530.00	7,524.51	7,448.04	21,398.98	913.42		20,485.56
Dec	12/10 - 01/10	0.019924	5,121.26	530.00	7,524.51	6,614.67	19,905.85	811.22		19,094.63
Jan	01/10 - 02/11	0.019924	5,557.68	530.00	7,524.51	7,178.34	20,915.78	880.35		20,035.43
Feb	02/11 - 03/11	0.019924	6,074.11	530.00	7,524.51	7,845.37	22,110.87	962.15		21,148.72
Mar	03/11 - 04/09	0.019924	6,382.06	530.00	7,524.51	8,243.11	22,823.50	1,010.93		21,812.57
Apr	04/09 - 05/11	0.019924	6,765.55	530.00	7,524.51	8,482.01	23,454.53	1,071.68		22,382.86
May	05/11 - 06/10	0.019924	7,931.98	530.00	8,456.80	9,657.13	26,754.67	1,256.44		25,498.22
Jun	06/10 - 07/13	0.018869	9,211.09	530.00	8,852.36	10,647.39	29,460.03	1,540.63		27,919.39
Jul	07/13 - 08/12	0.018869	8,117.29	530.00	8,825.08	10,188.84	27,854.37	1,357.69		26,496.69
Aug	08/12 - 09/10	0.018869	7,529.79	530.00	8,586.38	9,766.22	26,591.57	1,259.42		25,332.15
Sep	09/10 - 10/09	0.019924	6,958.42	530.00	8,456.80	8,987.55	25,089.58	1,102.23		23,987.35
Oct	10/09 - 11/10	0.019924	6,869.80	530.00	7,624.76	8,600.36	23,779.73	1,088.19		22,691.54
Totals			82,285.52	6,360.00	95,949.22	103,659.03	290,139.44	13,254.34	0.00	276,885.10

A preliminary estimate of the implementation cost was obtained from a Bryan, Texas contractor based upon your site description.[2] The amount of the estimate for labor and materials is $40,000, and it includes cutting the driveways and the electrical work, as well as the major equipment items in Table 1.5.

Table 1.5. Estimated conductor requirements.

Load, KVA	Length (ft)	Type	# of Sets
500	219	#350	2
750	122	#500	3
1000	72	#750	3

Simple Payback (yr)

= Implementation Costs (4) ÷ Total Savings ($/yr)

= $40,000 ÷ $12,949.70/yr

= 3.1 years

[2] Estimate from Britt Rice Electric, College Station, (409) 693-4076. Based on 4 wire lines with 4" pvc conduit.

ECO #2

AIR CONDITIONER MANAGEMENT

Recommended Action

Replace forty-one manual thermostats with electronic thermostats which should be programmed to a) setback the temperature during unoccupied hours in the office spaces in Building A, and to b) turn off the air handler units in the manufacturing areas of Buildings A and B during unoccupied hours.

Summary of Estimated Savings and Implementation Costs

The estimated annual energy savings from cooling are 19,345 kwh/yr or 66 million Btu/yr worth $730/yr. The estimated annual energy savings from heating are 768 million Btu/yr or 763 MCF worth $3,580/yr. There are no demand savings for this ECO. The total annual energy savings are 834 million Btu/yr worth $4,310/yr. The implementation costs come to $6,150, yielding a simple payback of 1.4 yrs.

Current Observations and Operations

The air conditioning units are controlled with 41 separate thermostats (23 in Building A and 18 in Building B) which are set at an average temperature of 75°F in the summer and 73°F in the winter. Conditioning is not needed from 6:00 pm to 6:00 am and on weekends in Building A. Conditioning is not needed from 12:00 midnight to 7:00 am and on weekends in Building B. This ECO recommends replacing each manual thermostat with an electronic programmable thermostat programmed for night setback of the office areas and night shut-off of the manufacturing areas. Annual cooling requirements of the office spaces can be reduced by increasing the unoccupied set point of the thermostat to 80°F. Annual heating requirements of the office spaces can be reduced by reducing the unoccupied setpoint of the thermostat to 60°F. The manufacturing spaces annual heating and cooling requirements will be reduced by turning the system off during the unoccupied hours.

Calculations

This ECO examines heat transfer due to a difference in air temperature of the facilities and the outside air. The energy (Q) supplied by heating or removed by cooling with the air conditioning system is given by:

$$Q = \sum \{U \times A \times \Delta T \times H\}$$

where,

Q = energy supplied or removed from envelope, Btu/yr

U = the overall heat transfer coefficient of the building, Btu/(hr•ft^2•F°)

A = surface area of building envelope, ft^2

ΔT = temperature difference between the interior and exterior temperatures, F°

H = operating hours at each bin temperature,[1] hr/yr.

The heat transfer coefficient, U is given as the reciprocal of the sum of the resistances of the individual building envelope components to heat flow or,

$$U = 1 \div \Sigma R$$

where the resistance R is in units of hr•ft^2•°F/Btu.

---

[1]Bin data from U.S. Air Force Facility Planning & Design, Engineering Weather Data for Ellington AFB, Houston, Tx., Doc. Div/US Doc. Dept D301.7:88-29/2.

Energy savings for this ECO are calculated using these basic equations and the procedure given in the "Simplified Calculation Form for Programmable Thermostats" of the "Loan STAR Audit Guidelines and Training Manual". For the calculations, the U value of the walls, roof, and windows must be known. They are determined in the following section.

U Values[2]

Walls with ambient exterior	R ($hr \bullet ft^2 \bullet °F/Btu$)
Surface coefficient, interior	0.33
Heavyweight concrete, 5 in.	0.42
Surface coefficient, exterior	0.69
Total - R	1.44

U-Value $1 \div R = 0.69 = U_{wa}$

Glass with ambient exterior: Negligible, glass made up less than one percent of total surface area.

Roof	R ($hr \bullet ft^2 \bullet °F/Btu$)
Surface coefficient, interior	0.33
6" insulation	20.0
2" heavyweight concrete	0.17
Felt membrane, three layers	0.87
Surface coefficient, exterior	0.69
Total - R	22.1

U-Value $1 \div R = 0.045 = U_{rf}$

[2] Values of R are taken from the 1989 ASHRAE Fundamentals Handbook, Table 11 p26.15.

Data:

Building A: Office areas

Wall area with ambient exterior[3]	$A_{w,o}$	= 9,800 ft^2
Roof area[4,5]	$A_{rf,o}$	= 16,800 ft^2

Building A: Manufacturing areas

Wall area with ambient exterior[6]	$A_{w,a}$	= 11,800 ft^2
Roof area[5,7]	$A_{rf,a}$	= 36,600 ft^2

Building B: Manufacturing areas (entire building)

Wall area with ambient exterior[8]	$A_{w,b}$	= 27,000 ft^2
Roof area[5,9]	$A_{rf,b}$	= 50,400 ft^2

U value of wall, both buildings	U_{wa}	= 0.69 Btu/hr•ft^2•°F
U value of roof, both buildings	U_{rf}	= 0.045 Btu/hr•ft^2•°F
Average thermostat set point - cooling season	T_{ac}	= 75°F
Average thermostat set point - heating season	T_{ht}	= 73°F
Proposed cooling season setback temperature (office only) .	$T_{cs,o}$	= 80°F
Proposed heating season setback temperature (office only) .	$T_{hs,o}$	= 60°F
Cooling equipment efficiency[10]	E_c	= 8.57 Btu/Watt-hr
Heating system efficiency (assumed)	η	= 80%
Avoided cost of electrical, building A[11]		= $.041/kwh
Avoided cost of electrical, building B		= $.028/kwh

---

[3] Estimated by EADC personnel. Based on 612.5 linear feet of wall area with ambient exterior times a wall high of 16 feet.

[4] Roof areas with missing or damaged insulation was treated as insulated.

[5] Estimated by EADC personnel. Based on a 589.5 ft by 85.5 ft building footprint with the office areas occupying approximately one third of the total building area.

[6] Estimated by EADC personnel. Based on 737.5 linear feet of wall area with ambient exterior times a wall high of 16 feet.

[7] Estimated by EADC personnel. Based on a 589.5 ft by 85.5 ft building footprint with the manufacturing areas occupying approximately one third of the total building area.

[8] Estimated by EADC personnel. Based on 589.5 ft by 85.5 ft building footprint times a wall height of 20 feet.

[9] Estimated by EADC personnel. Based on 589.5 ft by 85.5 ft building footprint.

[10] ASHRAE Handbook and Product Directory-1981 System Volume, page 43.10. This is the efficiency for a compressor and auxiliaries in the range of 3 to 25 tons, air cooled.

[11] The avoided cost of energy for meter W62181917 (building A, original area) of $0.041 was used for the entire building. The smaller area in the addition to building A had a avoided cost of energy of $0.054. Actual savings in building A may be higher, but was considered negligible.

Building A's office area energy savings due to thermostat setback can now be calculated by taking the difference of the energy supplied to or removed from the building, without setback and with setback. Table 2.1 shows the bin hour calculation for Building A, office area without night setback and Table 2.2 shows the bin hour calculation for Building A, office area, with night setback. The energy savings for Building A's office area are the differences between corresponding energy values in Table 2.1 and Table 2.2.

Building A's manufacturing area energy savings and all of Building B's energy savings due to night shut-off will be the calculated as the energy which would have been supplied without night shut-off. Table 2.3 shows the bin hour calculation for Building A, Manufacturing areas with night shutoff of the system. Table 2.4 shows the bin hour calculation for Building B with night shutoff of the system.

Because of the internal heat gains and the low heat loss rates that exist in these buildings, heating of the building will not be expected until the outside temperature drops to perhaps 65°F or lower. Therefore Tables 2.1-2.3 do not include any heating savings in the 72°F and 67°F temperature bins. Additional, most of Building B's natural gas usage appears be for the hot boxes, thereby causing most of the space heating to be obtained from losses from the hot boxes.[12] Because the hot boxes are operated twenty-four hours per day, any savings in night shut off of Building B during the heating season will minimal and while recommended, was neglected in our calculations in Table 2.4.

---

[12] Table 6 in the Plant Energy Consumption section shows average gas use of 92.9 MCF/mo for the months of June, July, August and September when no comfort heating is needed. This energy is likely used by the hot boxes. This rate of use of gas over the whole year would be 1115 MCF or over 90% of the energy used in Building B.

Table 2.1: Energy Bin-hour Calculation for Building A (without Night Set-back)

			<-------- Cooling	--------->	<--- Heating --->
TEMP BINS (deg F)	BINS' Tavg (deg F)	Hours per Year	BLDG A Qa (Btu/yr)	BLDG A Qa (kwh/yr)	BLDG A Qa (Btu/yr)
100/104	102	0	0	0	0
95/99	97	4	661,584	102	0
90/94	92	45	5,751,270	885	0
85/89	87	158	14,254,128	2,193	0
80/84	82	451	23,734,326	3,651	0
75/79	77	1123	16,885,428	2,598	0
70/74	72	950	0	0	0
65/69	67	701	0	0	0
60/64	62	573	0	0	47,385,954
55/59	57	496	0	0	59,662,848
50/54	52	440	0	0	69,466,320
45/49	47	367	0	0	71,736,756
40/44	42	261	0	0	60,828,138
35/39	37	158	0	0	42,762,384
30/34	32	77	0	0	23,734,326
25/29	27	22	0	0	7,608,216
20/24	22	6	0	0	2,300,508
15/19	17	2	0	0	842,016
Totals		5834	61,286,736	9,429	386,327,466

Table 2.2: Energy Bin-hour Calculation for Building A (with Night Set-back)

			<-------- Cooling	--------->	<--- Heating --->
TEMP BINS (deg F)	BINS' Tavg (deg F)	Hours per Year	BLDG A Qa (Btu/yr)	BLDG A Qa (kwh/yr)	BLDG A Qa (Btu/yr)
100/104	102	0	0	0	0
95/99	97	4	511,224	79	0
90/94	92	45	4,059,720	625	0
85/89	87	158	8,314,908	1,279	0
80/84	82	451	6,781,236	1,043	0
75/79	77	1123	0	0	0
70/74	72	950	0	0	0
65/69	67	701	0	0	0
60/64	62	573	0	0	0
55/59	57	496	0	0	11,186,784
50/54	52	440	0	0	26,463,360
45/49	47	367	0	0	35,868,378
40/44	42	261	0	0	35,319,564
35/39	37	158	0	0	27,320,412
30/34	32	77	0	0	16,208,808
25/29	27	22	0	0	5,458,068
20/24	22	6	0	0	1,714,104
15/19	17	2	0	0	646,548
Totals		5834	19,667,088	3,026	160,186,026

Table 2.3: **Energy Bin-hour Calculation for Night Shut-off (Building A's Manufacturing areas)**

			<-------- Cooling	--------->	<--- Heating --->
TEMP BINS (deg F)	BINS' Tavg (deg F)	Hours per Year	BLDG A Qa (Btu/yr)	BLDG A Qa (kwh/yr)	BLDG A Qa (Btu/yr)
100/104	102	0	0	0	0
95/99	97	4	861,432	133	0
90/94	92	45	7,488,585	1,152	0
85/89	87	158	18,559,944	2,855	0
80/84	82	451	30,903,873	4,754	0
75/79	77	1123	21,986,094	3,382	0
70/74	72	950	0	0	0
65/69	67	701	0	0	0
60/64	62	573	0	0	61,700,067
55/59	57	496	0	0	77,685,504
50/54	52	440	0	0	90,450,360
45/49	47	367	0	0	93,406,638
40/44	42	261	0	0	79,202,799
35/39	37	158	0	0	0
30/34	32	77	0	0	0
25/29	27	22	0	0	0
20/24	22	6	0	0	0
15/19	17	2	0	0	0
Totals		5834	79,799,928	12,277	402,445,368

Table 2.4: **Energy Bin-hour Calculation for Night Shut-off (Building B, Entire Building)**

			<-------- Cooling	--------->	<--- Heating --->
TEMP BINS (deg F)	BINS' Tavg (deg F)	Hours per Year	BLDG B Qa (Btu/yr)	BLDG B Qa (kwh/yr)	BLDG B Qa (Btu/yr)
100/104	102	0	0	0	0
95/99	97	0	0	0	0
90/94	92	0	0	0	0
85/89	87	12	3,009,312	463	0
80/84	82	119	17,408,034	2,678	0
75/79	77	573	23,949,108	3,684	0
70/74	72	519	0	0	0
65/69	67	364	0	0	0
60/64	62	290	0	0	0
55/59	57	255	0	0	0
50/54	52	228	0	0	0
45/49	47	204	0	0	0
40/44	42	165	0	0	0
35/39	37	105	0	0	0
30/34	32	60	0	0	0
25/29	27	18	0	0	0
20/24	22	4	0	0	0
15/19	17	2	0	0	0
Totals		2918	44,366,454	6,826	0

Note: To protect against freezing pipes or other liquids in the plant, night shutoff in the manufacturing areas should not occur below 40°F. Therefore, Table 2.3 and Table 2.4 do not show any heating energy savings for the bin hours below 40°F. Following Tables 2.1-2.4 are sample calculations showing how the values in the tables were obtained.

COOLING ENERGY SAVINGS

__Cooling Energy Savings (Btu/yr)__:

Building A, Office areas (without night setback) as shown in Table 2.1.

$= [U_{wa}$ (Btu/hr•ft²•°F) $\times A_{w,o} + U_{rf}$ (Btu/hr•ft²•°F) $\times A_{r,o}$ (ft²) $\times (T_{bin} - T_{ac})$(°F) $\times$ H (hr/yr)

The cooling energy cost (without set-back) for the 95/99°F bin is

$= [0.69$ Btu/hr•ft²•°F $\times$ 9,800 ft² + 0.045 Btu/hr•ft² •°F $\times$ 16,800 ft²] $\times$ (97 - 75)°F $\times$ 4 hr/yr

= 661,584 Btu/yr

The total annual cooling energy over all temperature bins (without setback) is

= 61,286,736 Btu/yr

Building A, Office areas (with night setback) as shown in Table 2.2.

$= [U_{wa}$ (Btu/hr•ft²•°F) $\times A_{w,o} + U_{rf}$ (Btu/hr•ft²•°F) $\times A_{r,o}$ (ft²) $\times (T_{bin} - T_{cs,o})$(°F) $\times$ H (hr/yr)

The cooling energy cost (with setback) for the 95/99°F bin is

$= [0.69$ Btu/hr•ft²•°F $\times$ 9,800 ft² + 0.045 Btu/hr•ft² •°F $\times$ 16,800 ft²] $\times$ (97 - 80)°F $\times$ 4 hr/yr

$= 511{,}224$ Btu/yr

The total annual cooling energy over all temperature bins (with setback) is

$= 19{,}667{,}088$ Btu/yr

Net savings Building A, Office areas

= Annual cooling energy (without setback) - Annual cooling energy (with setback)

$= 61{,}286{,}736$ Btu/yr - $19{,}667{,}088$ Btu/yr

$= 41{,}619{,}648$ Btu/yr

Building A, Manufacturing areas, as shown in Table 2.3. (This energy will be the cooling energy savings if night turn-off is used)

$= [U_{wa}\ (\text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F}) \times A_{w,a} + U_{rf}\ (\text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F}) \times A_{r,a}\ (\text{ft}^2) \times (T_{bin} - T_{ac})({}^\circ\text{F})$

$\times H\ (\text{hr/yr})$

The cooling energy cost for the 95/99°F bin is

$= [0.69\ \text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F} \times 11{,}800\ \text{ft}^2 + 0.045\ \text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F} \times 36{,}600\ \text{ft}^2]$

$\times (97 - 75){}^\circ\text{F} \times 4\ \text{hr/yr}$

$= 861{,}432$ Btu/yr

The total annual cooling energy over all temperature bins is

$= 79{,}799{,}928$ Btu/yr

Building B, as shown in Table 2.4. (This energy will be the cooling energy savings if night turn-off is used)

$= [U_{wa}\ (\text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F}) \times A_{w,b} + U_{rf}\ (\text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F}) \times A_{r,b}\ (\text{ft}^2) \times (T_{bin} - T_{ac})({}^\circ\text{F})$

$\times H\ (\text{hr/yr})$

The cooling energy cost for the 85/89°F bin is

$= [0.69\ Btu/hr \bullet ft^2 \bullet °F \times 27{,}000\ ft^2 + 0.045\ Btu/hr \bullet ft^2 \bullet °F \times 50{,}400\ ft^2]$

$\times (87 - 75)°F \times 12\ hr/yr$

= 3,009,312 Btu/yr

The total annual cooling energy over all temperature bins is

= 44,366,454 Btu/yr

<u>Net Cooling Load Savings (million Btu/yr)</u>

= Cooling Energy Savings (Btu/yr) ÷ 10^6 Btu/Btu (million Btu/yr)

= [41,619,648 Btu/yr + 79,799,928 Btu/yr](Building A)

+ 44,366,454 Btu/yr (Building B)

= 165,786,030 Btu/yr ÷ 10^6 Btu/million Btu

= 166 million btu/yr

<u>Net Cooling Savings (kwh/yr and million Btu/yr)</u>

= Cooling savings (Btu/yr) ÷ cooling equipment efficiency (Btu/watt)

÷ 1,000 watts/KW

= [121,419,576 Btu/yr (Building A) + 44,366,454 Btu/yr (Building B)]

÷ 8.57 Btu/watt-hr ÷ 1,000 watts/KW

= 14,168 (Building A) + 5,177 kwh/yr (Building B)

= 19,345 kwh/yr

= 19,345 kwh/yr × 0.003412 million Btu/kwh

= 66 million Btu/yr

Net Cooling Savings ($/yr)

= Net cooling energy savings (kwh/yr) × avoided cost of energy ($/kwh)

= 14,168 kwh/yr × $0.041/kwh (Building A)

+ 5,177 kwh/yr × $0.028/kwh (Building B)

= $581/yr + $145/yr

= $730/yr

HEATING ENERGY SAVINGS

Heating Energy Savings (Btu/yr):

Building A, Office areas (without night setback) as shown in Table 2.1.

$= [U_{wa}$ (Btu/hr•ft²•°F) $\times A_{w,o} + U_{rf}$ (Btu/hr•ft²•°F) $\times A_{r,o}$ (ft²) $\times (T_{ht} - T_{bin})$(°F)

× H (hr/yr)

The heating energy cost (without set-back) for the 60/64°F bin is

= [0.69 Btu/hr•ft²•°F × 9,800 ft² + 0.045 Btu/hr•ft² •°F × 16,800 ft²] × (73 - 62)°F

× 573 hr/yr

= 47,385,954 Btu/yr

The total annual heating energy over all temperature bins (without setback) is

= 386,327,466 Btu/yr

Building A, Office areas (with night setback) as shown in Table 2.2.

$= [U_{wa}$ (Btu/hr•ft²•°F) $\times A_{w,o} + U_{rf}$ (Btu/hr•ft²•°F) $\times A_{r,o}$ (ft²) $\times (T_{hs,o} - T_{bin})$(°F)

× H (hr/yr)

The heating energy cost (with setback) for the 55/59°F bin is

= [0.69 Btu/hr•ft²•°F × 9,800 ft² + 0.045 Btu/hr•ft² •°F × 16,800 ft²] × (60 - 57)°F

$\times$ 496 hr/yr

= 11,186,784 Btu/yr

The total annual heating energy over all temperature bins (with setback) is

= 160,186,026 Btu/yr

Net savings Building A, Office areas

= Annual heating energy (without setback) - Annual heating energy (with setback)

= 386,327,466 Btu/yr - 160,186,026 Btu/yr

= 226,327,466 Btu/yr

Building A, Manufacturing areas, as shown in Table 2.3. (This energy will be the heating energy savings if night turn-off is used)

$$= [U_{w,a}\ (\text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F}) \times A_{w,a} + U_{rf}\ (\text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F}) \times A_{r,a}\ (\text{ft}^2) \times (T_{ht} - T_{bin})({}^\circ\text{F})$$

$$\times H\ (\text{hr/yr})$$

The heating energy cost for the 60/64°F bin is

$$= [0.69\ \text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F} \times 11{,}800\ \text{ft}^2 + 0.045\ \text{Btu/hr}\bullet\text{ft}^2\bullet{}^\circ\text{F} \times 36{,}600\ \text{ft}^2]$$

$$\times (73 - 62){}^\circ\text{F} \times 573\ \text{hr/yr}$$

= 61,700,067 Btu/yr

The total annual heating energy over all temperature bins is

= 402,445,368 Btu/yr

Building B, no heating savings calculated in Table 2.4 due to the heating effects of the hot boxes located in this building.

<u>Net Heating Load Savings (million Btu/yr)</u>

= Heating Energy Savings (Btu/yr) $\div$ 10^6 Btu/Btu (million Btu/yr)

= [226,141,440 Btu/yr + 402,445,368 Btu/yr](Building A)

+ 0 (Building B)

= 628,586,808 Btu/yr ÷ 10^6 Btu/million Btu

= 629 million Btu/yr

Net Gas Savings (million Btu/yr and MCF/yr)

The value above will be further increased because it is supplied by a furnace with an assumed efficiency η of 80%. The energy consumption of the furnace is:

= Net heating load savings ÷ 0.80

= 629 million Btu/yr ÷ 0.80

= 786 million Btu/yr

and the net gas savings is:

= furnace consumption (million Btu/yr) ÷ conversion factor (million Btu/MCF)

= 786 million Btu/yr ÷ 1.03 million Btu/MCF

= 763 MCF/yr

Net Heating Savings ($/yr)

= Net heating savings (MCF/yr) × avoided cost of energy ($/MCF)

= 763 MCF/yr × $4.69/MCF

= $3,580/yr

Total Energy Savings (million Btu/yr)

= Cooling energy savings (million Btu/yr) + Heating energy savings (million Btu/yr)

= 66 million Btu/yr + 786 million Btu/yr

= 852 million Btu/yr

Total Energy Cost Savings ($/yr)

= Total cooling cost savings ($/yr) + total heating cost savings ($/yr)

= $730/yr + $3,580/yr

= $4,310/yr

Implementation Cost ($)

The estimated cost of installing forty one electronic programmable thermostats is:

= 41 units × Cost per unit[13] ($/unit)

= 41 units × $150/unit

= $6,150

Simple Payback (yr)[14]

= Implementation cost ($) ÷ total cost savings ($/yr)

= $6,150 ÷ $4,310/yr

= 1.4 yr

---

[13] Cost obtained from Means Mechanical Cost Data, 1992, pg255, line 157-420-5200. Price given includes the locking cover from line 157-420-5100.

[14] Using the quoted price of $8,170 from Fresh Air, Air Conditioning and Heating proposal dated September 28, 1992, for the installation of the T8600 Chromotherm III thermostat, the simple payback would be 1.9 years.

ECO #3

DELAMP FLUORESCENT LIGHTING

Recommended Action

Remove one half of the fluorescent tubes from fixtures in the large item storage area of the warehouse in Building A, or 46 of the 92 tubes. Remove twelve of the forty fluorescent tubes from fixtures in the breakroom in Building A. The tubes should be removed in pairs from the fixtures and the ballast serving each fixture should be disconnected.

Summary of Estimated Savings and Implementation Costs

The estimated energy savings from the implementation of this ECO are 12100 kwh/yr or 41.3 million Btu/yr, worth $490/yr. The demand savings are 82 KVA•mo/yr, worth $670/yr. The total annual savings for this ECO is $1,160/yr. The implementation cost for realization of this ECO is $475. Simple payback occurs in 0.4 yrs.

Current Operations and Observations

The large item area of the warehouse in Building A is currently lit with 92 eight foot fluorescent lamps in 46 fixtures with two lamps each. It could not be determined what model of lamps these were; but, the majority of eight foot lamps at this facility are the Philips model F96T12/CW/HO/EW lamps. It is assumed that these lamps are the same model. Nominal wattage of these lamps is 95 watts and these are energy efficient fluorescent lamps. Light intensity measured with a light meter indicated 30 footcandles (fc).

The Illuminating Engineers Society (IES) standard for a facility like this is 15 fc.[1] This light level can be achieved by removing one half of the current lamps.

The small item area of the warehouse had a light intensity of 20 fc, which is satisfactory. It is recommended that no change be made to this area of the warehouse.

The breakroom in building A is lit with 40 fluorescent lamps in 20 fixtures of two lamps each. Each lamp is eight foot long and it was assumed that they, like the majority of eight foot lamps in the facility, are the Philips F96T12/CW/HO/EW. Light intensity measured with a light meter indicated 75 fc. The IES standard for a facility like this is 50 fc.[2] This level can be achieved by removing one third of the lamps. However, it is recommended that 12 lamps be removed from six of the fixtures in evenly spaced intervals throughout the room. This will lower the light level to 52 fc.

In the walk through of these facilities it was noticed that the vast majority of fluorescent lamps were of the energy efficient type, and it is evident that a program of using these lamps has already been in progress. This is commendable and should be continued.

---

[1] IES Lighting Handbook 1981 Reference Volume, Appendix A, pp. 2-5,2-13.

[2] IES Lighting Handbook 1981 Reference Volume, Appendix A, pp. 2-5,2-6.

Calculations

Data:

Avoided cost of electrical energy	$0.041/kwh
Avoided cost of electrical demand	$9.32/KVA
Current no. of lamps Warehouse large item area	92
Measured Light Intensity Warehouse large item area	30 fc
Current no. of lamps Breakroom	40
Measured Light Intensity Breakroom	75 fc
Ballast Factor[3]	1.1
Operating Hours	1,992 hrs/yr
Lamp Wattage	95 watt/lamp

The light level to be expected by delamping these areas is a straight forward calculation. The projected light level is equal to the current light level (fc) times the ratio of the number of lamps after delamping divided by the number of lamps before the delamping. Delamping one half of the lamps will drop the light level by one half. This is what is recommended for the large item area of the warehouse. For the breakroom the level can be decreased by one third, from 75 fc to 50 fc. However, it is not workable to do this with 20 fixtures. It is satisfactory to remove 12 lamps in 6 fixtures to reduce the light level to 52 fc (75 fc × 12 lamps/40 lamps). These levels will still be at or above the IES Standards.

Warehouse

Energy Savings (kwh/yr)

= No. lamps removed × Lamp Size (watt/lamp) × Ballast Factor

× Operating Hours (hr/yr) × 1KW/1000 watts

= 46 lamps × 95 watt/lamp × 1.1 × 1,992 hr/yr × 1KW/1000 watts

[3] The ballast factor accounts for the energy drawn by the fluorescent ballasts and is 1.1. This value is taken from a University City Science Center sample report.

= 9600 kwh/yr

<u>Energy Savings (million Btu/yr)</u>

= Energy Savings (kwh/yr) × 0.00342 million Btu/kwh)

= 9600 kwh/yr × 0.003412 million Btu/kwh

= 32.8 million Btu/yr

<u>Energy Cost Savings ($/yr)</u>

= Energy savings (kwh/yr) × Avoided cost of electricity ($/kwh)

= 9600 kwh/yr × $0.041/kwh

= $390/yr

<u>Demand Savings (KVA●mo/yr)</u>

= No. lamps removed × Lamp size (watt/lamp) × 12 mo/yr × 1 KVA/1000 watt × Ballast Factor

= 46 lamps × 95 watt/lamp × 12 mo/yr × 1 KVA/1000 watt × 1.1

= 57.0 KVA●mo/yr

<u>Demand Cost Savings ($/yr)</u>

= Demand savings (KVA●mo/yr) × Avoided Cost of demand ($/KVA)

= 57.0 KVA●mo/yr × $9.32/KVA●mo

= $530/yr

<u>Breakroom</u>

<u>Energy Savings (kwh/yr)</u>

= No. lamps removed × Lamp Size (watt/lamp) × Ballast Factor × Operating Hours × 1 KW/1000 watts

= 12 lamps × 95 watt/lamp × 1.1 × 1,992 hrs/yr × 1KW/1000 watts

= 2500 kwh/yr

<u>Energy Savings (million Btu/yr)</u>

= Energy Savings (kwh/yr) × 0.00342 million Btu/kwh)

= 2500 kwh/yr × 0.003412 million Btu/kwh

= 8.5 million Btu/yr

<u>Energy Cost Savings ($/yr)</u>

= Energy savings (kwh/yr) × Avoided cost of electricity ($/kwh)

= 2500 kwh/yr × $0.041/kwh

= $100/yr

<u>Demand Savings (KVA/yr)</u>

= No. lamps × Lamp Size (watt/lamp) × Ballast Factor × 12 mo/yr

× 1KVA/1000 watt

= 12 lamps × 95 watt/lamp × 1.1 × 12 mo/yr × 1.0 KVA/1000 watts

= 15.0 KVA•mo/yr

<u>Demand Cost Savings ($/yr)</u>

= Demand savings (KVA/yr) × Avoided Cost of demand ($/KVA)

= 15.0 KVA•mo/yr × $9.32/KVA•mo

= $140/yr

<u>Total Cost Savings ($/yr)</u>

= Electrical Energy Savings (warehouse and breakroom) + Demand Cost Savings

(warehouse and breakroom)

= $390/yr + $100/yr + $530/yr +$140/yr

= \$1160/yr

Implementation Cost

The implementation cost of this ECO is the cost of labor to remove the lamps and disconnect the ballasts. There are 23 fixtures in the warehouse and six in the breakroom that are recommended for removal, or a total of 29 fixtures. The time to remove the lamps and disconnect the ballast is estimated to be 30 minutes per fixture. Total time is then 14.5 hours (29 fixtures × 30 minutes/fixture × 60 minutes/hr). The labor cost is computed using the following data:[4]

Data:

Electricians Labor Cost inc. O & P	\$38.95/hr
Houston City Cost Index, Labor	0.839

The labor cost is determined by multiplying the labor cost times the city cost index. The labor cost corrected to Houston is \$32.68/hr (\$38.95/hr × 0.839). The total labor cost for disconnecting the 29 fixtures, which is estimated to take 14.5 hours, is \$470 (14.5 hours × \$32.68/hr).

Simple Payback

Simple payback is computed as:

= Implementation Costs (\$) ÷ Total cost savings (\$/yr)

= \$470 ÷ \$1,160/yr

= 0.4 yr

[4] Means Repair & Remodeling Cost Data 1992, R. S. Means Co., Inc., Kingston MA, pp. 436, inside back cover.

ECO #4

REPLACE QUARTZ LAMPS WITH HIGH PRESSURE SODIUM LAMPS

Recommended Action

Replace the six, 250-watt quartz lamps on the outside of Building A with 70-watt high pressure sodium lamps.

Summary of Estimated Savings and Implementation Costs

The estimated energy savings from the implementation of this ECO are 4260 kwh/yr or 14.5 million Btu/yr, worth $190/yr. There are no demand savings so the annual savings for this ECO is $190/yr. The implementation cost for realization of this ECO is $570. The simple payback occurs in 3.0 yrs.

Current Operations and Observations

Currently there are six, 250-watt quartz lamps operating on the outside of Building A to provide site lighting during the hours of darkness. These quartz lamps produce approximately 4800 lumens.[1] Each of these lamps can be replaced by a 70-watt high pressure sodium lamp that will produce approximately 6300 lumens.[2] The high pressure sodium lamps cost more than the quartz lamps, but they last much longer. Average lifetimes are 2,000 hrs[1] for the quartz lamps versus 24,000 hours[2] for the high pressure sodium lamps.

---

[1] W. W. Grainger General Catalog No. 381, pp. 625.

[2] W. W. Grainger General Catalog, pp. 643

Calculations

Data:

Avoided cost of electrical energy	$0.041/kwh
Avoided cost of electrical demand	$9.32/KVA
Annual Operation Hours[3]	4732 hrs/yr
Ballast Factor for High Pressure Sodium Lamps[4]	1.25
Cost of Quartz Lamp[5]	$17.72/lamp
Cost of High Pressure Sodium Lamp[6]	$33.57/lamp

Energy Use by Quartz Lamps (kwh/yr)

= No. lamps × Lamp Size (watt/lamp) × Operating Hours × 1 KW/1000 watt

= 6 lamps × 250 watt/lamp × 4732 hrs/yr × 1 KW/1000 watt

= 7100 kwh/yr

Energy Use by High Pressure Sodium Lamps (kwh/yr)

= No. lamps × Lamp Size (watt/lamp) × Ballast Factor × Operating Hours × 1 KW/1000 watt

= 6 lamps × 70 watt/lamp × 1.25 × 4732 hr/yr × 1KW/1000 watt

= 2500 kwh/yr

Energy Savings (kwh/yr)

= Energy Use by Quartz Lamps - Energy Use by High Pressure Lamps

= 7100 kwh/yr - 2500 kwh/yr

---

[3] 13 hr/day × 7 days/wk × 52 wks/yr = 4732 hr/yr. This is average operation of 13 hrs/day, allowing for the lamps to be on one half hour before sundown and after sunup.

[4] Values from a University City Science Center sample report.

[5] W. W. Grainger General Catalog No. 381, pp. 625.

[6] W. W. Grainger General Catalog No. 381, pp.643.

= 4600 kwh/yr

Energy Savings (million Btu/yr)

= Energy Savings (kwh/yr) × 0.00342 million Btu/kwh)

= 4600 kwh/yr × 0.003412 million Btu/kwh

= 15.7 million Btu/yr

Energy Cost Savings ($/yr)

= Energy savings (kwh/yr) × Avoided cost of electricity ($/kwh)

= 4600 kwh/yr × $0.041/kwh

= $190/yr

Implementation Cost

The implementation costs associated with this ECO include the material cost of the high pressure sodium fixtures, the labor costs to install them, and the cost of the high pressure sodium lamps.

Data:

City Cost Index - Houston - Materials[7] 1.035
City Cost Index - Houston - Labor[8] 0.839
Uncorrected Material Cost of High Pressure Sodium Fixtures[8] ... $47.12/fixture
Uncorrected Labor Cost to Install Fixtures[9] $15.38/fixture
Cost of High Pressure Sodium Lamp[9] $33.57/lamp

[7] Means Repair & Remodeling Cost Data 1992, R. S. Means Co., Kingston, MA, 1992, pp.436

[8] Means Repair & Remodelling Cost Data 1992, R. S. Means Co., Kingston MA, 1992, pp. 236 line # 160-140-1350.

[9] W. W. Grainger General Catalog No. 381, pp.643.

Fixture Material Cost ($/fixture)

= Uncorrected Material Cost ($/fixture) × City Cost Index Materials

= $47.12/fixture × 1.035

= $48.77/fixture

Fixture Labor Cost ($/fixture)

= Uncorrected Labor Cost ($/fixture) × City Cost Index Labor

= $15.38/fixture × 0.839

= $12.90/fixture

Total Fixture Material and Labor Cost ($/fixture)

= Fixture Material Cost + Fixture Labor Cost

= $48.77 + $12.90/fixture

= $61.67/fixture

Implementation Cost ($)

= No. fixtures × [Total Fixture Material and Labor Cost + lamp cost]

= 6 fixtures [$61.67/fixture + $33.57/lamp]

= $570

Simple Payback

Simple payback is computed as:

= Implementation Costs ($) ÷ Total cost savings ($/yr)

= $570/yr ÷ $190

= 3.0 yr

ECO #5

NATURAL GAS SALES TAX EXEMPTION

Recommended Action

Perform a predominant use study on the use of natural gas in the plant to show that the predominant use (over 50%) of energy is for manufacturing, and claim exemption from state sales tax on this basis.

Summary of Estimated Savings and Implementation Costs

There are no energy savings associated with this ECO. The anticipated annual cost savings associated with this ECO are $790. The implementation costs are estimated to be $1,000. The simple payback is 1.3 years.

Current Operations and Observations

Presently, sales tax is being paid on gas service in the amount of $790 per year, (see Table 6, where the total sales tax for both buildings is $790). According to the State of Texas Comptroller, "direct use of natural gas or electricity in manufacturing which includes fabricating and processing, and in providing lighting, cooling, and heating in the manufacturing area..." will be considered as noncommercial tax-exempt use.

A tax-exempt status may be obtained by submitting a certificate of exemption supported by a predominant use study which should be kept on file in the plant. Both the certificate and the predominant use study can be completed by an engineer who is a professional engineer or a graduate of an accredited engineering college. Copies of the Texas tax code and the required exemption certificate are included in Appendix C of this report.

ECO #6

CLOSE FUME HOODS

Recommended Action

Close the fume hoods in the etching and developing room after operation hours.

Summary of Estimated Savings and Implementation Costs

The annual energy savings from cooling are 1,870 kwh/yr or 6 million Btu/yr worth $77/yr. The annual energy savings from heating are 11 million Btu, or 11 MCF/yr worth $52/yr. There are no demand savings for this ECO. The total cost savings amount to $130/yr for each vent. There is no implementation cost to turn off a vent; therefore, the simple payback is immediate.

Note: We were only able to measure flow rates at one vent because of hazardous liquids and lack of accessibility. Therefore, this ECO calculates the savings from closing the one vent whose flow rate was measured. We estimate (and recommend) that closing the other fume hoods would result in similar savings.

Current Observations and Operations

The manufacturing areas of this facility are fully air conditioned all year. The plant has been advised to use thermostat set-back but has not made a decision. The average maintained temperatures are 73°F for heating and 75°F for cooling (see ECO #2). The vents in the developing and etching room were left on after operations ceased. There are three five-horsepower fans servicing this room. When the fume hoods are closed, no conditioned air is vented to the ambient.

Calculations

Data:

Annual operation hours
- Plastic and Molding (Building A) .... 1,992 hr/yr
  - Air conditioning hours .... 8,760 hr/yr
- Building B .... 3,984 hr/yr
  - Air conditioning hours .... 8,760 hr/yr

Conditioned space
- A/C set point[1] .... 75°F, 50% rel. hum., 28.3 Btu/lbm of dry air
- Cooling equipment efficiency[2] .... E_c = 8.57 Btu/watt-hr

Avoided cost of electricity
- Building A $0.041/kwh

Avoided cost of natural gas 4.69/MCF
Conversion Factor .... 0.003412 million Btu/kwh
Specific heat of air[3] .... 0.24 Btu/lbm-°F

Cooling Savings (Btu/yr)

The energy (Q) removed by the vent that must be cooled with the air conditioning system is given by

$$Q = M \times \Delta H \times Time$$

where,

Q = energy removed from envelope, Btu/yr
M = the mass flowrate of conditioned air being vented to ambient (lbm/hr)
ΔH = enthalpy difference between the interior and exterior air, (Btu/lbm of air)
Time = non-operating hours at temperature bin, (hr/yr)

The mass flowrate (M) is constant for the room at constant temperature. We measured the velocity, therefore, the mass flowrate can be calculated.

---

1 Estimated.

2 ASHRAE Handbook and Product Directory-1981 Systems Volume, page 43.10. This is the efficiency for a compressor and auxiliaries in the range of 3 to 25 tons, air cooled.

3 Introduction to Thermodynamics, Classical and Statistical, R. Sonntag, and G. Van Wylen, p7822, John Wiley & Sons publishing.

Mass flowrate (M) is given by:[4]

$$M = V\rho^4 = 11{,}200\ ft^3/hr \times 14.7\ (lbf/in^2) \times 144\ (in^2/ft^2)$$

$$\div \{53.34\ [(ft\text{-}lbf)/(lbm\text{-}°R) \times (460+75)°R\}$$

$$= 831\ lbm/hr\ .$$

Energy savings from eliminating the exhaust due to sensible and latent heat are calculated below. This approach neglects the energy to run the fan, and assumes that the vent can be closed during non-operation hours. The cooling savings for the 80/84°F bin as shown in Table 6.1 are

$$Q = M\ (lbm/hr) \times [H_{bin} - H_{room}]\ (Btu/lbm\ of\ dry\ air) \times bin\ hours\ (hr/yr)$$

$$\times\ fraction\ of\ time\ not\ needed$$

$$= 831\ lbm/hr \times [35.8 - 28.3]\ (btu/lbm\ of\ dry\ air) \times 892\ hr/yr$$

$$\times (1 - 1{,}992/8760) hrs/hrs$$

$$= 4{,}295{,}000\ btu/yr$$

The total annual cooling savings are given in Table 6.1 as

$$= 16{,}030{,}000\ btu/yr$$

<u>Cooling Savings (kwh/yr)</u>

$$= Cooling\ savings\ (Btu/yr) \div cooling\ equipment\ efficiency\ (Btu/watt)$$

$$\div 1{,}000\ watts/KW$$

$$= 16{,}030{,}000\ Btu/yr \div 8.57\ Btu/watt\text{-}hr \div 1{,}000\ watts/KW$$

$$= 1{,}870\ kwh/yr$$

---

[4] Estimated by EADC personnel. The fume hood opening is 18" x 8'. We measured an average velocity of 70 ft/min over an area 4" x 8' and zero ft/min over the remainder. Therefore the volumetric flow rate is calculated as: 70 ft/min × 4 inches ÷ 12 inches/ft × 8 ft × 60 min/hr = 11,200 ft^3/hr.

Cooling Savings (million Btu/yr)

= Cooling savings (kwh/yr) × conversion factor (million Btu/kwh)

= 1,870 kwh/yr × 0.003412 million Btu/kwh

= 6 million Btu/yr

Cooling Cost savings ($/yr)

= Cooling energy savings × avoided cost of energy

= 1,870 kwh/yr × $0.041/kwh

= $77/yr

Heating Cost (million Btu/yr)

The energy (Q) removed by the vented air that must be heated is given by

$$Q = M \times C_p \times \Delta T \times Time$$

where,

Q = energy supplied or removed from envelope, Btu/yr
M = the mass of conditioned air being vented to ambient (lbm/hr)
C_p= specific heat of air at room temperature (0.24 Btu/lbm-°F)
ΔT = temperature difference between the interior and exterior temperatures, F°
Time = non-operating hours at temperature bin, (hr/yr)

Energy savings from eliminating the exhaust due to sensible heat are calculated below. This approach neglects the energy to run the fan, and assumes that this vent can be turned off during non-operation hours. The heating savings are calculated as

$$Q = M\ (lbm/hr) \times C_p\ (Btu/lbm\text{-}°F)\ \ [T_{bin} - T_{room}]\ (°F) \times Time\ (hr/yr)$$

$$\times\ Time\ (hr/yr) \quad \times\ fraction\ of\ time\ not\ needed$$

The sample bin-hour calculation for the 50/54°F bin in Table 6.1 is

= 831 lbm/hr × 0.24 Btu/lbm-°F × [73-52]°F × 580 hr/yr × (1 - 1,992/8760)

= 1,877,000 Btu/yr

The total annual heating savings are given in Table 6.1 as

= 11,145,000 Btu/yr

Heating Cost (MCF/yr)

= Heating Savings (million Btu/yr) ÷ conversion factor (million Btu/kwh)

= 11.1 million Btu ÷ 1.03 MCF/million Btu

= 11 MCF/yr

Table 6.1: Energy Bin-hour Savings[5]

Temp deg F	Tavg	Rel Hum	Enthalpy Btu/lbm	Hrs/yr	Cooling Q Btu/yr	Cooling Q kwh/yr	Heating Q Btu/yr
100/104	102	30	40	1	7,512	1	
95/99	97	40	40	41	307,983	36	
90/94	92	50	40	304	2,283,583	267	
85/89	87	55	37.6	625	3,731,816	435	
80/84	82	62	35.8	892	4,295,200	501	
75/79	77	70	33.8	1530	5,402,707	630	
70/74	72	71		1279			197,078
65/69	67	72		964			891,244
60/64	62	70		782			1,325,464
55/59	57	70		668			1,646,891
50/54	52	48		580			1,876,791
45/49	47	43		460			1,842,891
40/44	42	39		321			1,533,329
35/39	37	34		186			1,031,773
30/34	32	30		87			549,632
25/29	27	25		25			177,201
20/24	22	20		7			55,009
15/19	17	15		2			17,258
Total					16,029,000	1,870	11,144,561
Cost						$77	$51

5 Bin data from U.S. Air Force Facility Planning & Design, Engineering Weather Data, for Ellington AFB, Houston, Tx., Doc. Div/US Doc. Dept D301.7:88-29/2.

Heating Cost ($/yr)

= Avoided cost of natural gas ($/MCF) × avoided consumption (MCF/yr)

= $4.69/MCF × 11 MCF/yr

= $52/yr

Total Cost Savings ($/yr)

= Total cooling savings + total heating savings

= $77/yr + $52/yr

= $130/yr

Implementation Cost ($)

There is no implementation cost associated with this ECO. Application only involves turning off this vent when it is not required. Personnel should make sure that high concentrations of fumes will not result from turning of a vent.

Simple Payback (yr)

The simple payback is immediate since there is no implementation cost.

APPENDIX A:

MISCELLANEOUS GENERAL SERVICE RATE SCHEDULE

HOUSTON LIGHTING & POWER

Effective: May 16,1991

HOUSTON LIGHTING & POWER COMPANY
HL&P 64

MISCELLANEOUS GENERAL SERVICE-MGS

AVAILABILITY

At all points where facilities of adequate capacity and the required phase and suitable voltage are adjacent to the premises to be served. Where adequate capacity or service of the type desired by the customer is not adjacent to the premises to be served, additional contract arrangements may be required prior to service being furnished.

APPLICATION

For all Electric Service required for commercial or industrial purposes supplied at one premises through one Point of Delivery and measured through one Meter. Not applicable to Standby or Supplementary service except in conjunction with appropriate agreements. Applicable to Temporary service subject to provisions of Service Extension Policy. The service furnished may not be remetered or submetered by the Customer for resale except pursuant to lawful submetering regulations of a regulatory authority with jurisdiction.

TYPE OF SERVICE

Single or three-phase, 60 hertz and at one of the Company's standard service voltages as described in the Company's Service Standards.

MONTHLY BILL

The monthly bill shall be the sum of calculations made under (1) below or the calculation made under (2) below, whichever is higher, plus the applicable adjustments calculated under (3) below.

(1) Rate

(a) Facilities Charge	$29.25 per month.
(b) Demand Charge	$3.40 per Kva for each Billing Kva over 10 Kva.

(c) Energy Charge

During the billing months of May through October, \$.056937 per Kwh for the first 1250 Kwh or for 125 Kwh per Kva of Billing Kva, whichever is greater;

or

During the billing months of November through April, \$.053281 per Kwh for the first 1250 Kwh or for 125 Kwh per Kva of Billing Kva, whichever is greater; plus

\$.033279 per Kwh for the next 1700 Kwh or for 170 Kwh per Kva of Billing Kva, whichever is greater, plus

\$.007313 per Kwh for all additional Kwh

(d) Fuel Charge

Amount determined in accordance with Rider FC.

(2) Minimum Bill

The Facilities Charge in (1)(a) above unless expense and investment to serve Customer requires a special guarantee.

(3) Adjustments

(a) Plus an amount determined in accordance with Rider PCRF.

(b) For municipal accounts receiving service within the incorporated limits of such municipality which imposes a municipal franchise fee upon the revenues received by Company within that municipality and who have signed an appropriate Franchise Agreement, such account will receive a credit equal to the amount of franchise fees included in base charges for each account taking service under this Rate Schedule.

DETERMINATION OF KVA

The Billing Kva (kilovolt amperes) applicable to the Monthly Bill shall be the average Kva supplied during the 15 minute period of maximum use during the month then being billed as determined from meter readings.

PAYMENT

Bills are due when rendered. A bill for electric service is delinquent if payment is not received by the Past Due Date shown on the Electric Service Bill. The Past Due Date will not be less than sixteen (16) days from the date the bill is mailed to Customer. A one-time late payment charge of 3% of the entire bill exclusive of sales tax will be assessed if the total amount due is not received on or before the Past Due Date.

CONTRACT PERIOD

Open order unless a special condition requires a written contract.

NOTICE

Electric Service furnished under this rate schedule is subject to the Company's Terms and Conditions for the Sale of Electric Service, Sheet No. E1.

APPENDIX B:

LARGE GENERAL SERVICE RATE SCHEDULE

HOUSTON LIGHTING & POWER

Effective: May 16,1991

HOUSTON LIGHTING & POWER COMPANY
HL&P 67

LARGE GENERAL SERVICE-LGS

AVAILABILITY

At all points where facilities of adequate capacity and the required phase and suitable voltage are adjacent to the premises to be served. Where adequate capacity or service of the type desired by the customer is not adjacent to the premises to be served, additional contract arrangements may be required prior to service being furnished.

APPLICATION

To any customer for all Electric Service supplied at one premises through one Point of Delivery and measured through one Meter. Not applicable to Standby service except in conjunction with appropriate agreements. Applicable to Temporary service subject to the provisions of the Service Extension Policy. The service furnished may not be remetered or submetered by the Customer for resale except pursuant to lawful submetering regulations of a regulatory authority with jurisdiction.

TYPE OF SERVICE

Three phase, 60 hertz alternating current and at one of the Company's standard service voltages as described in the Company's Service Standards.

MONTHLY BILL

The monthly bill shall be the sum of calculations made under (1) below or the calculations made under (2) below, whichever is higher, plus the applicable adjustments stated under (3) below.

(1) Rate

(a) Facilities Charge	$530 per month.
(b) Demand Charge	
Primary Kva Charge	$4,092 which includes 600 Primary Kva plus $6.82 per Kva for all additional Primary Kva
Secondary Kva Charge	$2.40 per Kva for all Secondary Kva

(c) Energy Charge — $.025734 per Kwh for the first 295 Kwh per Primary Kva plus

$.007540 per Kwh for all additional Kwh.

(d) Fuel Charge — Amount determined in accordance with Rider FC.

(2) Minimum Bill

The Primary Kva Charge applicable to the current month plus the monthly Facilities Charge.

(3) Adjustments

(a) Plus an amount determined in accordance with Rider PCRF.

(b) For municipal accounts receiving service within the incorporated limits of such municipality which imposes a municipal franchise fee upon the revenues received by Company within that municipality and who have signed an appropriate Franchise Agreement, such account will receive a credit equal to the amount of franchise fees included in base charges for each account taking service under this Rate Schedule.

DEFINITION OF ON-PEAK HOURS AND OFF-PEAK HOURS

Company's On-Peak hours, for the purposes of this rate schedule, are designated as being from 8 a.m. to 10 p.m. each Monday through Friday starting on May 15 and continuing through October 15 each year. Labor Day and Independence Day (July 4) shall not be considered On-Peak. If July 4 occurs on Sunday then the following Monday shall not be considered On-Peak. The Company's On-Peak hours may be changed from time to time and Customer will be notified 12 months prior to such change becoming effective.

Company's Off-Peak hours, for the purposes of this rate schedule, are all hours of the year not designated as On-Peak hours.

DEFINITION OF ON-PEAK KVA, ANNUAL ON-PEAK KVA AND OFF-PEAK KVA

The terms "On-Peak Kva", "Annual On-Peak Kva" and "Off-Peak Kva" shall be defined as follows:

(1) On-Peak Kva is the average Kva supplied during the four fifteen minute periods of maximum use during the On-Peak hours of the billing month.

(2) Annual On-Peak Kva is the highest On-Peak Kva established in the 12 months ending with and including the current billing month. For billing purposes, Customer's Annual On-Peak Kva shall not be less than 600 Kva.

(3) Off-Peak Kva is the average Kva supplied during the four fifteen minute periods of maximum use during the Off-Peak hours of the billing month.

DETERMINATION OF PRIMARY KVA AND SECONDARY KVA TO BE USED IN CALCULATING THE BILL

The Primary Kva and the Secondary Kva to be used in calculating the Monthly Bill shall be determined in accordance with the following provisions:

(1) If the Off-Peak Kva is equal to or less than the Annual On-Peak Kva, the highest of the following will be billed as Primary Kva:

(a) The On-Peak Kva;
(b) The Off-Peak Kva;
(c) 85% of the Annual On-Peak Kva; or
(d) 600 Kva.

(2) If the Off-Peak Kva is greater than the Annual On-Peak Kva, then Annual On-Peak Kva, but not less than 600 Kva, will be billed as Primary Kva and the excess of the Off-Peak Kva over the Annual On-Peak Kva will be billed as Secondary Kva.

The above provision (2) is not applicable to either (a) new customers taking service for the first time during the period starting October 16 and continuing through May 14 or (b) for existing customers operating new facilities during such period. Under such circumstances, unless the Annual On-Peak Kva has been determined by mutual agreement, the Off-Peak Kva will be billed as Primary Kva until the following May 15.

PAYMENT

Bills are due when rendered. A bill for electric service is delinquent if payment is not received by the Past Due Date shown on the Electric Service Bill. The Past Due Date will not be less than sixteen (16) days from the date the bill is mailed to Customer. A one-time late payment charge of 3% of the entire bill exclusive of sales tax will be assessed if the total amount due is not received on or before the Past Due Date.

CONTRACT PERIOD

Not less than 1 year.

NOTICE

Electric Service furnished under this rate schedule is subject to the Company's Terms and Conditions for the Sale of Electric Service, Sheet No. E1.

APPENDIX C:

TEXAS TAX CODE

SALE AND USE TAX EXEMPTIONS

STATE OF TEXAS

COMPTROLLER OF PUBLIC ACCOUNTS

STATE SALES AND USE TAX

Rule 3.295. Natural Gas and Electricity. (Texas Tax Code §151.317).

(a) Definitions.

(1) Commercial use - Use by persons engaged in selling, warehousing, or distributing a commodity or use by persons engaged in selling a service, either professional or personal, including uses by the wholesale and retail trade, hotels, office buildings, preparation or storage of food for immediate consumption, and those persons providing taxable services.

(2) Electric utility - Any entity owning or operating for compensation in this state equipment or facilities for producing, generating, transmitting, distributing, selling, or furnishing electricity whose rates for the sale of electric power are set by the Public Utilities Commission under the Public Utility Regulatory Act. The term does not include:

(A) a qualifying small power producer or qualifying co-generator, as defined in the Federal Power Act, §3(17)(D) and §3(18)(C), as amended (16 U.S.C. §796(17)(D) and §796(18)(C)), or

(B) any person not otherwise a public utility that owns or operates in this state equipment or facilities for producing, generating, transmitting, distributing, selling, or furnishing electric energy to an electric utility, if the equipment or facilities are used primarily for the production and generation of electric energy for the person's own consumption.

(3) Fabrication - To make, build, create, produce, or assemble components of tangible personal property, or to make tangible personal property work in a new or different manner.

(4) Manufacturing - Every operation commencing with the first stage of production of tangible personal property and ending with the completion of tangible personal property. The first production stage means the first act of production and it does not include acts in preparation for production. For example, a manufacturer gathering, arranging, or sorting raw material or inventory is preparing for production. When production is completed, maintaining the life of tangible

personal property or preventing its deterioration is not a part of the manufacturing process. Tangible personal property is complete when it has the physical properties, including packaging, if any, that it has when transferred by the manufacturer to another. For the purposes of this rule, direct use of natural gas or electricity in manufacturing, which includes fabricating and processing, and in providing lighting, cooling, and heating in the manufacturing area, will be referred to as noncommercial use. Also see Rule 3.300 concerning Manufacturing; Custom Manufacturing; Fabricating; Processing.

(5) Other noncommercial uses - include:

(A) exploration for or production or transportation of material extracted from the earth;

(B) agriculture, including dairy or poultry operations and pumping water for farm and ranch irrigation;

(C) electrical processes such as electroplating, electrolysis, and cathode protection; or

(D) direct or indirect use, consumption, or loss of electricity by an electric utility engaged in the purchase of electricity for resale.

(6) Remodeling - To make tangible personal property belonging to another over again without causing a loss of its identity, or without causing the property to work in a new or different manner.

(7) Processing - The physical application of the materials and labor necessary to modify or to change the characteristics of tangible personal property. The repair of tangible personal property by restoring it to its original condition is not considered processing of that property. The property being processed may belong either to the processor or the customer, the only tests being whether the property is processed and whether it will ultimately be sold. The mere packing, unpacking, or shelving of a product to be sold will not be considered to be processing of that product. Direct use of natural gas or electricity in processing will be referred to as noncommercial use. Processing does not include remodeling or any action taken to prolong the life of tangible personal property or to prevent a deterioration of the tangible personal property being held for sale.

(8) Residential use - Use in a family dwelling or in a multifamily apartment complex or housing complex or nursing home or in a building or portion of a building occupied as a home or residence. For purposes of the exemption for residential use of natural gas and electricity, nursing

homes qualify for exemption only for periods beginning after December 31, 1987.

(b) Sales tax applicable. The furnishing of natural gas or electricity is a sale of tangible personal property. All the provisions in the Tax Code, Chapter 151, applying to the sale of tangible personal property, apply to the sale of natural gas or electricity.

(c) Commercial uses taxable; noncommercial uses exempt. The tax imposed by the Tax Code, Chapter 151, must be collected on the sale of natural gas or electricity for commercial use. The sale of natural gas or electricity for residential use or for use directly in manufacturing, processing, or for other noncommercial uses is exempt.

(d) Predominant use.

(1) Natural gas or electricity used during a regular monthly billing period for both exempt and taxable purposes under a single meter is totally exempt or taxable based upon the predominant use of the natural gas or electricity measured by that meter. A person who performs a processing, manufacturing, or other noncommercial function continually must establish predominant use on 12 consecutive months of use.

(2) If, in the regular course of business, a person performs a processing, manufacturing, or other noncommercial function only part of the year and a nonprocessing, nonmanufacturing, or other commercial function for the remainder of the year, the predominant use may be established for that period of time the processing, manufacturing, or other noncommercial function occurs based on the predominant use during that period.

(3) When determining the predominant use of natural gas or electricity, utilities used to operate production machinery and for lighting, cooling, and heating in the manufacturing area are exempt. Gas and electricity used to operate lighting, cooling, and heating in manufacturing support areas are taxable. Manufacturing support areas include, but are not limited to, storage, engineering, office and accounting areas, research and development, and break, eating, and restroom facilities. Utilities used in an area open to the public for the purpose of marketing a product ready for sale are taxable. Utilities used to operate other nonproduction machinery or equipment are taxable.

(4) Persons whose use of natural gas or electricity is solely in family dwellings will not be required to furnish exemption certificates.

(5) A person whose use is in multifamily apartment complexes, housing complexes, nursing homes, or other residential buildings may be required to issue an exemption certificate if one is necessary for the utility company to distinguish exempt residential use from taxable commercial use.

(e) Determining predominant use: Utility studies.

(1) Persons claiming a sales tax exemption because the predominant use of natural gas and electricity through a single meter is for processing, manufacturing, fabricating, or other noncommercial use must have performed a utility study to establish this predominant exempt use. The study must list all uses of the utility, both exempt and nonexempt, the times of usage, the energy used, and whether the use was taxable or exempt. Twelve consecutive months of utility usage must be a part of the study. The kilowatt rating or BTU rating, duty factor, where needed for cycling equipment, and electrical or natural gas computations must be certified by a registered engineer or a person with an engineering degree from an accredited engineering college. The owner of the business must certify that all items using natural gas or electricity (depending on which utility is covered by the study) are listed and that the hours of use for each item are correct. The certification of both the engineer and the owner must appear on the face of the study. If the owner of the business appoints an agent to act on the owner's behalf, the power of attorney must clearly state that the agent is attempting to qualify the principal for a sales tax exemption, and if a refund of sales tax is involved, the power of attorney must also state that a sales tax refund will be made by the state through the utility company. A person in business less than 12 consecutive months may still apply for a sales tax exemption if a registered engineer or a person with an engineering degree performs a study based upon projected uses which shows the predominant use as exempt. A person claiming an exemption based upon estimated use must be able to support the claimed exemption with a study of actual use after 12 consecutive months of operation if so requested by the Comptroller.

(2) The study must be completed and on file at the location of the person claiming the exemption at the time an exemption certificate is submitted to the utility company. Without the study, the claim for exemption will be presumed to be invalid. Persons obtaining a sales tax refund without a valid study will be assessed tax, penalty, and interest by the Comptroller on the full amount of the refund, if the exemption is not proved. If the exemption certificate is fully completed with all information required by this rule and bears an original seal of a registered engineer or is attached to a signed statement with an original signature from the owner of the business and a person with an engineering degree from an accredited engineering college,

as required by section (e)(1) of this rule, the utility company is not required to make any additional inquiry before honoring the exemption request.

(3) The Comptroller may request a copy of the study for review, either before or after the sales tax exemption is granted. Neither the Comptroller, by reviewing a study nor the utility company by accepting an exemption certificate, is confirming the study's accuracy. Tax, penalty, and interest will be assessed on the business owner if the study is proven to be incomplete or inaccurate to the extent that the predominant use of the natural gas or electricity is taxable.

(4) If a sales tax refund is being claimed retroactively, the study must take into account any changes in equipment or other items using utilities, any changes in business activities, and any changes in square footage being served by the meter.

(f) Exemption certificates.

(1) Noncommercial users must issue exemption certificates to the utility company to claim a sales tax exemption or to obtain a refund of sales tax. The exemption certificate must be specific as to the reason for the claimed exemption. For example, if a person is claiming that the predominant use of the utility is for processing, the reason for the exemption must state, "A valid and complete study has been performed which shows that (insert the actual exempt percentage) of the natural gas or electricity is for processing tangible personal property for sale in the regular course of business."

(2) The exemption is valid only as long as the person continues to use natural gas and electricity in a manner which is for predominantly exempt purposes. At the time the uses of the utilities change so that the predominant use is commercial, it is the person's responsibility to immediately notify the utility company in writing that the exemption is no longer valid.

(g) Transportation of a material extracted from the earth.

(1) Sales or use tax is not due on natural gas or electricity used to transport a material or its components extracted from the earth. Examples of materials or components extracted from the earth would be oil, natural gas, coal or coal slurry.

(2) Sales or use tax is due on natural gas or electricity used to transport a product which was manufactured from a material extracted from the earth. Products which were manufactured from a material extracted from the earth

include substances which do not exist in nature or are not components of crude oil, natural gas, coal or other minerals extracted from the earth.

(3) A material will not be considered to be manufactured when an additive is combined with a material for ancillary reasons, for example, odorant added to natural gas.

(h) Exemptions limited. Natural gas and electricity exemptions are limited to those noncommercial uses covered specifically in the Tax Code, §151.317.

Effective Date: June 25, 1991
Filed with Secretary of State: June 4, 1991

JOHN SHARP
Comptroller of Public Accounts

Rule 3.287. Exemption Certificates. (Texas Tax Code §§151.054, 151.155, 151.156, 151.418).

(a) Definition. Exemption certificate - A document which, when properly executed, allows the tax-free purchase of an item that would otherwise be subject to tax. A purchaser claiming an exemption because the item purchased is for resale must issue a resale certificate to the seller. See Rule 3.285 concerning Resale Certificate; Sales for Resale. There is no provision in the sales and use tax act for an exemption number or a tax exempt number to be issued or used in connection with an exemption certificate.

(b) Who may issue an exemption certificate. An exemption certificate of the type described in this rule may only be issued by one of the following:

(1) an organization that has qualified for exemption under the Tax Code, §151.309 and §151.310. See Rule 3.322 concerning Exempt Organizations;

(2) a person purchasing an item which is exempt under the Tax Code, Chapter 151, Subchapter H.

(c) Maquiladora exemption and direct payment permits.

(1) People who make purchases using direct pay permits should refer to Rule 3.288 concerning Direct Payment Procedures and Qualifications.

(2) People who make purchases using maquiladora exemption permits should refer to Rule 3.358 concerning Maquiladoras.

(d) Acceptance of exemption certificate.

(1) All gross receipts of a retailer are subject to sales or use tax unless a valid and properly completed exemption certificate is accepted by the seller.

(2) A sale is exempt if the exemption certificate is accepted in good faith at the time of the transaction and the seller lacks actual knowledge that the claimed exemption is invalid.

(3) A person who issues an exemption certificate when purchasing a taxable item who knows at the time of purchase the item

will be used in a manner other than that expressed in the certificate is guilty of a criminal offense.

(4) The seller should obtain the properly executed exemption certificate at the time the taxable transaction occurs. All certificates obtained on or after the date the comptroller's auditor actually begins work on the audit at the seller's place of business or on the seller's records after the entrance conference are subject to verification. All incomplete certificates will be disallowed regardless of when they were obtained. The seller has 60 days from the date written notice is received by the seller from the comptroller in which to deliver the certificates to the comptroller. Written notice shall be given by the comptroller upon the filing of a petition for redetermination or claim for refund. For the purposes of this rule, written notice given by mail is presumed to have been received by the seller within three business days from the date of deposit in the custody of the United States Postal Service. The seller may overcome the presumption by submitting proof from the United States Postal Service or by other competent evidence showing a later delivery date. Any certificates delivered to the comptroller during the 60-day period will be subject to independent verification by the comptroller before any deductions will be allowed. Certificates delivered after the 60-day period will not be accepted and the deduction will not be granted.

(5) The exemption certificate will be valid if the seller received it in good faith from a purchaser and if the certificate states valid qualifications for an exemption. A retailer must be familiar with the exemptions that are available for the items the retailer sells.

(6) An exemption certificate is not acceptable when an exemption is claimed because tangible personal property is exported outside the United States. For proper documentation required for proof of export, see Rule 3.323 concerning Imports and Exports.

(e) Improper use of items purchased under an exemption certificate.

(1) When an item purchased under a valid exemption certificate is used in a taxable manner, whether the use is in Texas or outside the state, the purchaser is liable for payment of sales tax based on the fair market rental value of the item for the period of time used. The fair market rental value is the amount the purchaser would pay on the open market to rent the item for use. If the item has no fair market rental value, sales tax is due on the original purchase price. If the exemption certificate was invalid at the time of its issuance, the purchaser owes tax on the original purchase price.

(2) At any time the person using the item purchased under a valid exemption certificate may stop paying tax on the fair market rental value and instead pay sales tax on the original purchase price. When the person elects to pay sales tax on the purchase price, credit will not be allowed for taxes previously paid on the fair market rental value.

(3) Sales tax is not due when an item purchased under a valid exemption certificate is donated to an organization exempt from tax under the Tax Code, §151.309 or §151.310(a)(1) or (2).

(4) Contractors using equipment purchased under a valid exemption certificate on both taxable and exempt projects must account for tax based upon the provisions in Rule 3.291 concerning Contractors.

(f) Content of an exemption certificate. An exemption certificate must show:

(1) the name and address of the purchaser;

(2) a description of the item to be purchased;

(3) the reason the purchase is exempt from tax;

(4) the signature of the purchaser and the date; and

(5) the name and address of the seller.

(g) Purchases of taxable items by agents of the Federal Deposit Insurance Corporation (FDIC) or the Resolution Trust Corporation (RTC). The FDIC/RTC may purchase items tax free for use in operating a property or business to which they have title. An exemption certificate may be issued by either the FDIC/RTC or by persons acting as agents for the FDIC/RTC when purchasing items that are incorporated into or used on the property or business being managed. The certificate must state that the purchases are being made by or for the FDIC/RTC. The FDIC/RTC or persons managing property or a business for these corporations may issue an exemption certificate when:

(1) the FDIC/RTC provides documentation to the person managing the property or business showing that title to the property or business being managed was transferred to the FDIC/RTC; and

(2) the FDIC/RTC has entered into a written agreement with the person managing the property or business that designates that person as its agent and authorizes that person to make purchases on its behalf. The agreement must be in the person's files for review by the comptroller. It is not necessary to provide a copy of the agreement to suppliers.

ENERGY CONSERVATION SURVEY REPORT

Energy
Analysis &
Diagnostic
Center

Mechanical Engineering Department
Texas A&M University
College Station, Texas

ABSTRACT

This report describes work with two energy management programs at Texas A&M University. The first section of this report describes the Loans to Save Taxes and Resources (LoanSTAR) program and includes comparisons of the energy consumption for the commercial/institutional buildings being monitored under the program. LoanSTAR is a Texas statewide retrofit demonstration revolving loan program which incorporates a monitoring program to report and verify energy savings from energy conservation retrofits in commercial building.

The second section of this report is an audit of a medium size industrial plant in Texas as part of the Energy Analysis and Diagnostic Center (EADC) in the Mechanical Engineering Department at Texas A&M. The EADC is a Department of Energy funded program to help smaller manufacturing and industrial plants in the U.S. to control energy costs and improve profits by analyzing the plant's energy consumption and manufacturing operations and by recommending ways to improve the manufacturing or plant's energy efficiency.

Table of Contents

[i] The EADC report is a independent report completed in March 1993. See page 152 for a Table of Contents for the Energy Conservation Survey Report. The page numbering for Section II starts with page 1 after the Table of Contents page.

Introduction

This report is the development of a macro review of the energy consumption of the commercial/institutional buildings being monitored under the Texas LoanSTAR program. The resulting plots contain the normalized energy consumption index for each site over various time frames: pre-retrofit monitoring period, post-retrofit monitoring period, total LoanSTAR monitoring period, calendar year 1991 monitoring period and a calendar year 1992 monitoring period. Because the entry date into the LoanSTAR program differs for each site, some sites will not have data in all of the monitoring periods selected. The plots also contain the results of the LoanSTAR Annual Energy Consumption Report (AECR) for each site when available. The AECR is a summary, by sites, of the monthly energy consumption and energy savings resulting from the LoanSTAR retrofits. When a monitoring period contains no data, the plots show no energy consumption during that period.

The normalized energy consumption for each site is expressed by the following indexes (expressed as an Energy Utilization Index or EUI):[1]

Electrical energy consumption: The total electrical energy consumption measured during the time period (kWh), divided by the product of the time in hours and the building's gross conditioned area (ft^2). This results in an EUI for each site expressed in average Watts per square foot (W/ft^2)

Chilled water flow: The total chilled water flow during the period (gal), divided by the product of the time in hours and the building's gross conditioned area ($h\text{-}ft^2$). This results in an EUI for each site of gallons per hour per square foot ($gal/h\text{-}ft^2$).

---

[1]All indexes are corrected to reflect only the "good" data that exists in the LoanSTAR data base divided by the number of hours of this "good" data. i.e. A one year monitoring period should have 8,760 hours of data but due to hardware, software or other problems, only 7,000 hours of data may exist for the 8,760 hour period. Therefore, the indexes for 1991 (a one-year monitoring period) would be the sum of the 7,000 hours of data divided by the product of 7,000 and the building's gross conditioned area.

Chilled water energy consumption: The total chilled water thermal energy consumption measured during the time period (Btu^t), divided by the product of the time in hours and the building's gross conditioned area ($h\text{-}ft^2$). This results in an EUI for each site expressed in Btu^t per hour per square foot ($Btu^t/h\text{-}ft^2$).

Heating energy consumption (Condensate flow, feedwater flow or hot water flow measured): The total heating energy consumption measured during the time period (Btu), divided by the product of the time in hours and the building's gross conditioned area ($h\text{-}ft^2$). This results in an EUI for each site expressed in Btu per hour per square foot ($Btu/h\text{-}ft^2$)[2].

Heating energy consumption (Natural Gas fuel measured): The total heating energy consumption measured during the time period (Btu^f), divided the product of the time in hours and the building's gross conditioned area ($h\text{-}ft^2$). This results in an EUI for each site expressed in Btu per hour per square foot ($Btu/h\text{-}ft^2$)[3].

The final portion of this report is an Energy Diagnostic and Analysis Center (EADC) Energy Conservation Survey Report. An EADC report is conducted by a team of 3 to 4 Mechanical Engineering students and an EADC Mechanical Engineering staff member. Each student is assigned one or more Energy Conservation Opportunities (ECO) by the staff member during the audit walk through. One of the students is assigned as the Primary Report Author (PRA). The PRA is responsible for reviewing the last twelve months of utility bills for the plant, calculating an avoided cost for each type of energy consumed, and briefing of the other members prior to the audit date. The briefing includes month charts of the energy consumption for each utility meter in the plant as well as the calculations used in determining the avoided cost of energy. After the audit, the PRA is responsible for combining the other students' ECOs into the

---

[2]The LoanSTAR metering program measures condensate, feedwater and hot water thermal energy flow in gallons. LoanSTAR uses an average conversion factor of 9,075 Btu/gal.

[3]The LoanSTAR metering program measures natural gas consumption in cubic feet. LoanSTAR uses a conversion factor of 1,030 Btu/ft^3

report, writing the remaining portions of the report, and submitting the report to the staff member for review.

During the past year, I have attended three audits with the EADC program and have written several different types of ECOs in support of those audits. Additionally, the Energy Management in Industry course at Texas A&M provided the background and training to perform many of the calculations necessary to write-up the various different types of energy conservation opportunities or ECOs which can be identified in an industrial setting. As part of the EADC program, I was the primary report writer for one of the audits that I attended. That report is attached in its entirety in the appendix of this report .

The LoanSTAR Program[4]

In 1988, the Texas Governor's Energy Management Center (GEMC)[5] of Texas received approval from the U.S. Department of Energy to establish a $98.6 million statewide retrofit demonstration revolving loan program, i.e. the Loans to Save Taxes and Resources (LoanSTAR) program. The LoanSTAR program uses a revolving loan financing mechanism to fund energy-conserving retrofits in state, public school, and local government buildings. Retrofit projects are identified by energy audits conducted by engineering teams under contract to the GEO. Each retrofit competes for funds on the basis of the estimated payback period, ability to repay the loan through energy savings, engineering assessment of the viability of the retrofit, and the feasibility of metering the project effectively.

---

[4]Turner, W.D., 1990. "Overview of the Texas LoanSTAR Monitoring Program," *Proceedings of the Seventh Annual Symposium on Improving Building Systems in Hot and Humid Climates*, College Station, Texas: Texas A&M University. October 9-10, pp 28-34.
[5]In 1990, the GEMC was renamed the Governor's Energy Office (GEO).

Background

The projects funded by LoanSTAR primarily include retrofits to lighting, HVAC systems, building shell modifications, electric motors, energy management and control systems, boilers, and thermal storage systems. Retrofits using alternative or renewable energy systems and load management are also considered. The length of the loan can be up to four years. Repayments are made semiannually at an interest rate of 4.04%. Loan proceeds can be used to pay for the retrofit, engineering and design, and the installation expenses. The cost of the on-site metering and energy analysis is paid from the interest-income derived from the program. Total metering costs are held to three percent of all retrofit costs by the site.

LoanSTAR Organization[6]

Figure 1 is the organizational chart for the LoanSTAR Monitoring and Analysis program.

Monitoring the Buildings[7]

A unique feature of the LoanSTAR program is the Monitoring and Analysis Program (MAP) that was established to measure and report the energy savings from the retrofits. The MAP is a quality assurance measure to ensure that agencies purchasing retrofits receive real savings for their investment.

The major objectives of the MAP are to:

1) verify the energy and dollar savings of the retrofits,

---

[6]Turner, W.D. *et al.* 1993. "Texas LoanSTAR Monitoring and Analysis Program." *A Report to The Monitoring and Advisory Review Committee.* Austin, Texas, June 2-3

[7]Claridge, D.E., *et al* 1991. "Improving energy conservation retrofits with measured savings." *ASHRAE Journal.* October, pp. 14-22.

2) reduce energy costs by identifying operational and maintenance improvements,

3) improve retrofit selection in future rounds of the LoanSTAR program, and

4) initiate a data base of energy use in institutional and commercial buildings in Texas.

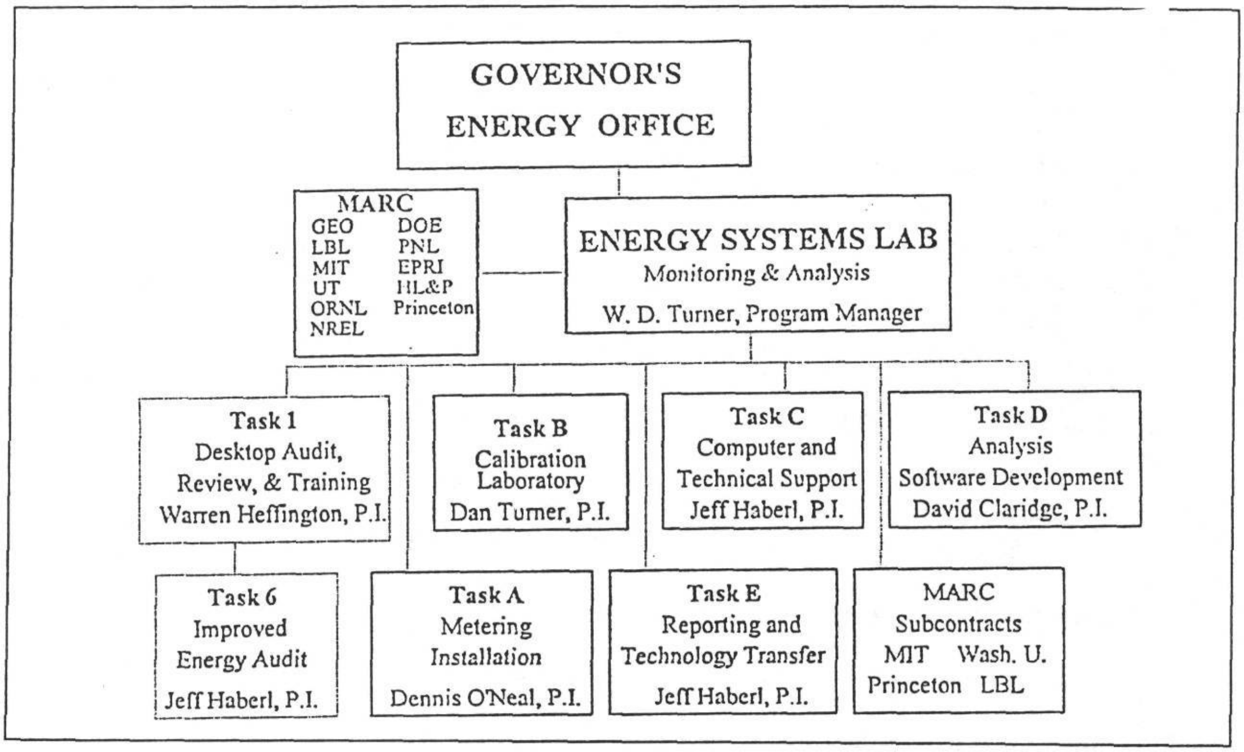


Figure 1: LoanSTAR organizational chart.

Currently, the program is monitoring hourly data from over 70 buildings[8] and 7 LoanSTAR weather stations using public domain polling procedures that collect information from microcomputer based field recorders. Additionally, LoanSTAR collects hourly weather data from 53 Natural Weather Service sites.

[8]Fifty four buildings had data collected by the end of December 1992, which is the cutoff point for this report. LoanSTAR has added over twenty buildings to the program since January 1993.

For each site, a monitoring plan is developed to verify the estimated energy savings. When possible, verification of savings includes measuring consumption before and after the retrofit, and then analyzing the data to account for weather, changes in building operation, etc.

Four levels of metering systems have been defined for the energy monitoring program. These levels attempt to accommodate the necessary data requirements with the funds available for monitoring the retrofits. The four levels are:

Level 0: Facility/whole-building utility data. These data range from monthly consumption data (based on utility bills) to weekly or daily utility metered data. Such data are useful for separating consumption into heating, cooling, and non-weather related consumption.

Level 1: Whole-building and limited sub-metered hourly data. Level 1 utilizes one- to four-channel data acquisition systems (DAS) or data loggers, and captures hourly whole-building thermal and electric measurements. In some cases, one or two sub-metered channels are included.

Level 2: Moderate sub-metered hourly data. This level has all the capabilities of the first two levels and also enables more detailed analysis for identifying the savings from specific retrofits and pinpointing building operational problems. Moderate sub-metered DAS are simple five- to twenty-channel systems.

Level 3: Detailed sub-metered hourly data. These systems typically include at least twenty channels of data. They are only cost-effective in larger facilities or groups of buildings.

This report includes only data from the Levels 1, 2 and 3 sites in the LoanSTAR program.

Calibration Laboratory[9]

The accuracy of metering sensors installed under the LoanSTAR program is a key part in ensuring a successful energy monitoring program. When analysis of the metered data is reported to the owners/operators of the facilities in the program, the report must be accurate in order for the LoanSTAR program to maintain confidence and reliability. To achieve this, a National Institute of Standards and Technology (NIST) traceable calibration laboratory was established at Texas A&M University. The laboratory has the capability to measure dry-bulb, wet-bulb, and dewpoint temperature, humidity, air and hydraulic pressure, air and liquid mass flow rates, air velocity, rpm, illumination levels, electrical energy, power factor and solar radiation.

Acquiring and Archiving Data[10]

Data collected under the LoanSTAR program includes: site description information, utility billing, and rate information, and electronically polled 15-minute and hourly consumption and influencing parameters, such as ambient temperature, humidity and indoor temperature. The 15-minute polled data is used predominantly for sites with thermal storage retrofits whereas most LoanSTAR sites are being polled for hourly consumption data.

A dedicated PC is assigned the task of polling each Data Acquisition System or DAS via a telephone modem weekly. Some interim checks are performed to assure that the systems are operational between weekly polling. Each week when the DASs are called, they perform several tasks, including: a check to see if the clock is still on time, resetting the clock if necessary, and down-loading the data to the LoanSTAR MAP Net (Monitoring and Analysis Program Network).

---

[9]Claridge, D.E., *et al* 1991. "Improving energy conservation retrofits with measured savings." *ASHRAE Journal.* October, pp. 14-22.
[10]Haberl, J. *et al.* 1990. 'The Texas LoanSTAR program: Acquiring and archiving data." *Proceedings of the Seventh Symposium on Improving Building Systems in Hot and Humid Climates.* College Station, Texas: Texas A&M University. October 9-10, pp. 47-52.

The LoanSTAR Map Net is a local area network designed to handle the data acquisition, archiving, computation, word processing and graphics needs of the program. It is based on a high performance UNIX server and industry-standard Ethernet cabling. The network includes over three gigabytes of disk space, over fifty 386/486-class workstations, two UNIX workstations, and several postscript quality laser printers.

Two of the primary objectives of the LoanSTAR software development are to: (1) collect, analyze, archive and distribute energy consumption data for those agencies directly participating in the program; and (2) develop and disseminate public domain building energy analysis tools that perform such processing. With the second objective in mind, provisions have been made for licensing and distributing software through the Texas Engineering Experiment Station (TEES) Office of Contracts and Grants. Software produced for the LoanSTAR program is public domain and is available at a modest distribution fee. Readers of the report who are interested in obtaining more information about the LoanSTAR program and/or information on the public domain software may contact Dr. Jeff Haberl at (409)845-6065.

Analysis of the Data[11]

The analysis of the LoanSTAR collected data is performed in several phases for each monitoring site. These include: verification /modification of audit assumptions, pre-retrofit analysis (with data when available or using calibrated models when data is not available), preliminary post-retrofit analysis, detailed post-retrofit analysis, interaction and feedback to agencies and operators, and reports.

---

[11]Claridge, D.E., *et al.* 1990. "Analysis of the Texas LoanSTAR data." *Proceedings of the Seventh Symposium on Improving Building Systems in Hot and Humid Climates.* College Station, Texas: Texas A&M University. October 9-10, pp. 53-60

The Analysis and Planning Task is responsible for selecting and developing analysis techniques, developing the necessary software and analyzing the collected data to:

(1) determine the energy and dollar savings of the retrofit;

(2) reduce energy costs by identifying operational and maintenance improvements at retrofitted facilities;

(3) identify the savings of individual retrofits, as feasible, in order to help improve the selection of future retrofit projects;

(4) initiate an end-use database of energy use for commercial/institutional buildings located in Texas.

This report represents the first comprehensive presentation of the LoanSTAR data by end uses and other categories as required under objective 4) above.

Micro versus Macro Analysis

Most of the analysis to date in the LoanSTAR program has been on a micro level for each site. The program has been developing monthly inspection plots for each site, a Monthly Energy Consumption Report (MECR) which provides the owners/operators of the facilities with building energy utilization, an Annual Energy Consumption Report (AERC) which details the annual energy utilization and savings for each site, and a Data Summary Note Book which plots the energy consumption for each site. All of these efforts have focused on each individual site without comparisons across the sites. Also, the MECR, AECR and other analysis activity has made extensive use of statistical modeling in order to predict weather-dependent energy consumption and to account for missing readings in the data.

The direction of this report involves taking a step back from the details of the micro analysis of the monthly data collected and to perform a macro review of all the data collected under the program. The plots which are contained later in this section are an attempt to look at the Energy Utilization Index (EUI) for different monitoring periods for each site. By comparing EUIs across the different buildings and different monitoring periods, the owners/operators of the facilities as well as the LoanSTAR staff, can view the performance of their buildings and compare the performance with other facilities in the program.

Of interest would be the sites with EUIs much higher or lower than other similar sites in the program. Sites which have a "grossly" high EUI might represent a location for an energy conservation project in the future, while a lower than expected EUI might represent a metering problem. Additionally, future retrofits and/or operation and maintenance's decisions can be evaluated based on a site's EUI which was not within an expected range of values. The macro review of the data does not try to account for the different weather-dependent energy consumption conditions that exist during the different monitoring periods, (as done by the micro analysis through statistical modeling of the data) and therefore, the indexes produced by the macro review will differ somewhat from the micro analysis indexes of the monthly consumption. Also, because the methods for calculating the macro indexes ignores periods with missing data, the macro indexes may be biased toward the periods where data is available, i.e. missing chilled water data during the summer months may bias the chilled water index towards the lower consumption readings produced during the winter months. Dispite these differences with the micro analysis, the macro review of the data will provide some interesting characteristics for the facilities in the program.

Starting with a zero based review of all the sites which were a part of the LoanSTAR program in 1992, each site was reviewed to determine what types of data were being collected, when the data collection was started (LoanSTAR start date), and when or if a energy retrofit has been started (retrofit start date and retrofit completion date)[12]. A spreadsheet was developed identifying each LoanSTAR site versus the types of data being collected for that site as well as similar spreadsheets for the monitoring start date, retrofit start date and retrofit completion date. Table 1 is the spreadsheet of the types of data collected under the LoanSTAR program for each site. Figure 2 is a graphically representation of the numbers in Table 1, showing the number and percentage of sites which have a particular data monitoring type being collected by LoanSTAR. Tables 2, 3 and 4 contain the dates for the LoanSTAR monitoring start date, retrofit start date and retrofit completion date, respectively.

A similar spreadsheet was constructed for the LoanSTAR and National Weather Service sites which provide weather data for use in the micro analysis of the consumption data. Table 5 is the weather site spreadsheet.

Several other spreadsheets, macros, UNIX programs, and other programs were developed over the course of the last year. Many were necessary to construct the plots contained later in this report while others are stand alone information from the LoanSTAR program. They are attached in the appendix of this reports.

[12]It was determined by the Analysis group, that the retrofit start date and retrofit completion date would not necessary correspond to the construction start and construction completion date. When the retrofit has no effect on the energy consumption at a site (by review of the timeline plot of the consumption) the retrofit start date and completion date would be the same (i.e. all of the monitored data would be either pre-retrofit or post-retrofit date). If the construction affected the energy consumption (i.e. closing portions of the building during construction) then the retrofit start date would correspond to the date that the effect is visible on the timeline plots of the consumption and retrofit completion date is the date the retrofits are operational (For some sites, the retrofit completion date will be after any "fine tuning" has occurred to the new systems, and could be several months after the construction contract is completed)

Types of Data collected under the LoanSTAR program as of December 1992

					Electric									Cooling		Heating					HVAC								
Site Dr	# of Bldg	# of Sites	LS Code	LS #	WBE kW	MCC kW	AHU kW	Lght kW	Elev kW	Spec kW	Cog kW	Pum kW	ChW kW	ChW Flow	ChW Btu	HW Btu	NG CFT	Con Flow	FW Flow	Ste Press	H/C Temp	CD RH	RAir Temp	RAir RH	Fan dP	SAir Temp	SAir RH	Misc	Total
			Texas A&M																										
	1	1	ZEC	001	1	1	1			1.001				1	1	1					1	1	1	1	1	1	1		14
			U. T Austin																										
	1	1	EDB	100	1		1					1		1	1			1											6
	1	1	UTC	101	1		1					1		1	1			1											6
	1	1	PCL	102	1		1					1		1	1			1											6
	1	1	WAG	105	1		1							1	1			1											5
	1	1	WEL	106	1		1					1		1	1			1											6
	1	1	BUR	107	1		1					1		1	1			1											6
	1	1	NUR	108	1		1			1.002		1		1	1			1											7
	1	1	WIN	114	1										1			1											3
	1	1	STD	115	1									1	1			1											4
	1	1	PAI	116	1									1	1			1											4
	1	1	WCH	117	1									1	1			1											4
	1	1	GAR	118	1		1					1		1	1			1											6
	1	1	GEA	119	1		1					1		1	1			1											6
			U.T.Arlington																										
	1	1	UNV	111	1		1							1	1			1											5
	1	1	BUS	112	1		1	1						1	1			1											6
	1	1	FNA	113	1		1			1.003				1	1			1											6
			State Capitol Complex																										
	1	1	SHB	201	1		1					1	1		1		1	1	1		1	1	1	1					12
	1	1	SFA	202	1	1	1	1				1	1		1		1		1		1	1	1	1	1				14
	1	1	JHR	203	1		1	1	1			1			1			1											7
	1	1	JER	205	1								1																2
	1	1	INS	206	1	1									1														3
	1	1	INX	207	1	1							1																3
	1	1	ARC	208	1	1									1														3
	1	1	WBT	209	1		1		1						1														4
	1	1	LBJ	210	1		1	1				1			1														5
	3	1	JHW	211	1					1.001				1	1														4
			U.T.H.S.C. San Antonio																										
	1	1	SAM	142			1							1	1														3
	1	1	SAD	141			1					1		1	1														4
			U.T.H.S.C. Houston																										
	1	1	SPH	300	1		1					1			1			1			1	1			1	1	1		10
	1	1	MSB	124	1		1	1						1	1			1											6

Table 1: Types of Data Collected under the LoanSTAR Program.

Types of Data collected under the LoanSTAR program as of December 1992

TYPES OF DATA COLLECTED

Site	# of	#of	LS	LS	Electric									Cooling		Heating					HVAC								
					WBE	MCC	AHU	LGH	Elev	Spec	Cog	Pum	ChW	ChW	ChW	HW	NG	Con	FW	Ste	H/C	CD	RAir	RAir	Fan	SAir	SAir	Misc	Total
Dr	Bldg	Sites	Code	#	kW	kW	kW	kW	kW	kW	kW	kW	kW	Flow	Btu	Btu	CFT	Flow	Flow	Press	Temp	RH	Temp	RH	dP	Temp	RH		
			Victoria ISD																										
	9	1	SHS	126	1								1		1		1												4
	2	1	VHS	127	1								1	1	1		1												5
			UTMB Galveston																										
	1	1	JSN	400	1							1		1	1			1											5
	1	1	CSB	401	1							1		1	1			1											5
	1	1	BSB	402	1							1		1	1			1											5
	1	1	MLB	403	1							1		1	1			1											5
	1	1	JSS	404	1							1		1	1			1											5
			Fort Worth ISD																										
	1	1	SIM	128	1			1									1												3
	1	1	DMS	129	1			1									1												3
			Miscellaneous Locations																										
	14	1	UTP	125	1					1.004					1														3
	5	1	TDH	130	1									1	1				1										4
	8	1	MDA	136	1					1.005		1	1	1	1		1	1		1									9
	6	1	UTD	137	1																								1
	3	1	COM	138	1																								1
	9	1	TAG	139	1									1	1		1												4
	18	1	DMC	143	1								1	1	1		1												5
	1	1	MCC	144	1								1																2
	1	1	WMH	145	1							1	1																3
	1	1	DCG	146	1		1					1	1	1	1		1												7
	11	1	SWT	149	1						1		1	1	1		1	1		1								1.006	9
	6	1	TST	150	1	1																							2
	26	1	MHR	151	1						1						1		1									1.007	5
	1	1	NHS	152	1	1		1					1				1												5
	1	1	CMS	153	1	1		1																					3
																													0
	162	**55**	**TOTAL**		53	8	23	9	2	6	2	22	13	32	43	1	13	27	4	2	4	4	3	3	3	2	2	2	283
	Percentage of Sites				96%	15%	42%	16%	4%	11%	4%	40%	24%	58%	78%	2%	24%	49%	7%	4%	7%	7%	5%	5%	5%	4%	4%	4%	

Site Dr: Type of Site Drawings	Spec: Special (See Misc. List)	HW: Hot water in BTU	CD RH: Cold Deck Relative Humity	Misc:	
WBE: Whole Bldg/Site Electric	Cog: Cogeneration(enegry from	NG: Natural Gas	RAir Temp: Return Air Temp	1.001 Computers	1.005
MCC: Motor Control Centers	Pump: Hot,cold, cond., or ChW	Con: Condensate return	RAir RH: Return Air Relative Humity	1.002 Tennis Courts	1.006 NG to Cogen and 50 psi steam
AHU: AHU or Fans	ChW (kW): Chiller Electric	FW: Feed water flow	Fan: Pressure drop across fan	1.003 Theater	
Lght: Interior Lights measured	ChW (Flow): Chiller flow	Ste: Steam pressure supplied	SAir Temp: Supply Air Tem	1.004 Central Utilities	1.007 NG to Cogen
Elev: Elevators	ChW (BTU): Chiller output	H/C Temp: Hot/Cold Deck T.	SAir RH: Supply Air Relative Humity		

Table 1: Continued...

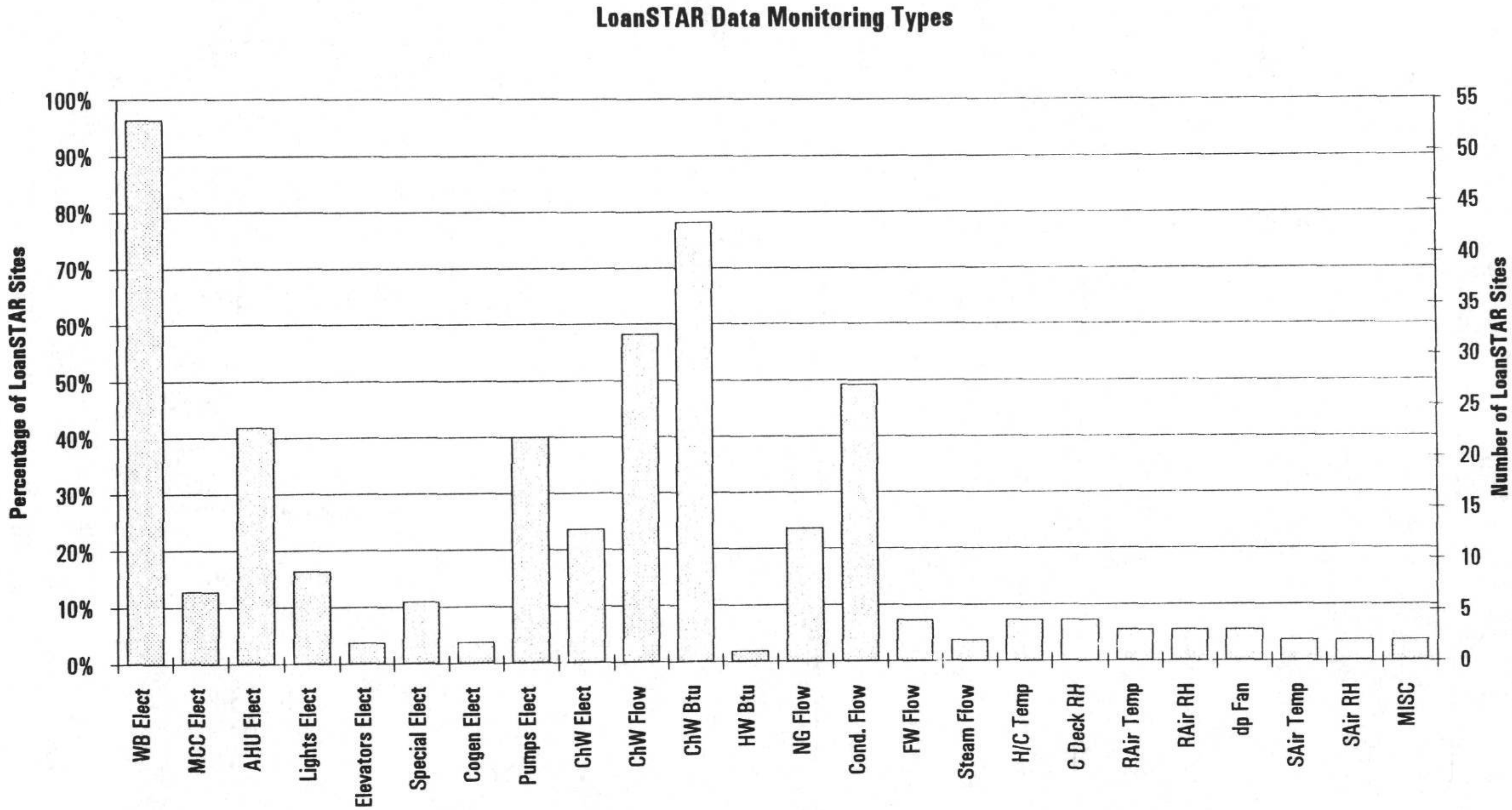


Figure 2: LoanSTAR Data Monitoring Types.

LoanSTAR Monitoring Start Date

		Electric									Cooling		Heating					HVAC						
LS Code	LS #	WBE kW	MCC kW	AHU kW	Lght kW	Elev kW	Spec kW	Cog kW	Pump kW	ChW kW	ChW Flow	ChW Btu	HW Btu	NG CFT	Con Flow	FW Flow	Ste Press	H/C Temp	CD RH	RAir Temp	RAir RH	Fan dP	SAir Temp	SAir RH
Texas A&M																								
ZEC	001	5/31/89	5/31/89	5/31/89			5/31/89				5/31/89	5/31/89	5/31/89					3/7/90	3/7/90	3/7/90	3/7/90	3/7/90	3/7/90	3/7/90
U. T Austin																								
EDB	100	10/13/90		10/13/90					10/13/90		10/13/90	10/13/90			10/13/90									
UTC	101	10/13/90		4/28/92					10/13/90		10/13/90	10/13/90			10/13/90									
PCL	102	10/8/90		10/8/90					10/8/90		10/8/90	10/8/90			10/8/90									
WAG	105	10/13/90		10/13/90							10/13/90	10/13/90			10/13/90									
WEL	106	10/13/90		10/13/90					10/13/90		10/13/90	10/13/90			10/13/90									
BUR	107	10/13/90		10/13/90					10/13/90		10/13/90	10/13/90			10/13/90									
NUR	108	10/13/90		10/13/90			10/13/90		10/13/90		10/13/90	10/13/90			10/13/90									
WIN	114	10/11/90										10/11/90			10/11/90									
STD	115	10/11/90										10/11/90			10/11/90									
PAI	116	10/10/90									10/10/90	10/10/90			10/10/90									
WCH	117	10/10/90									10/10/90	10/10/90			10/10/90									
GAR	118	10/13/90		10/13/90					10/13/90		10/13/90	10/13/90			10/13/90									
GEA	119	10/13/90		10/13/90					10/13/90		10/13/90	10/13/90			10/13/90									
U.T.Arlington																								
UNV	111	12/11/90		12/11/90							12/11/90	12/11/90			12/11/90									
BUS	112	12/22/90		12/22/90	12/22/90						12/22/90	12/22/90			12/11/90									
FNA	113	12/11/90		12/11/90			12/11/90				12/11/90	12/11/90			12/11/90									
State Capitol Complex																								
SHB	201	9/17/91		9/17/91					9/17/91	9/17/91		9/17/91		9/17/91	9/17/91	9/17/91		9/17/91	9/17/91	9/17/91	9/17/91			
SFA	202	3/12/90	3/12/90	3/12/90	3/12/90				3/12/90	3/12/90	1/14/92	3/12/90		3/12/90		1/14/92		3/12/90	3/12/90	3/12/90	3/12/90	3/12/90		
JHR	203	1/1/91		1/1/91	1/1/91	1/1/91			1/1/91			1/1/91			1/1/91									
JER	205	12/11/91								12/11/91														
INS	206	12/11/91	12/11/91									12/11/91												
INX	207	12/11/91	12/11/91							12/11/91														
ARC	208	12/11/91	12/11/91									12/11/91												
WBT	209	12/20/90		12/20/90		12/20/90						12/20/90												
LBJ	210	12/11/90		12/11/90	12/11/90				12/11/90			12/11/90												
JHW	211	3/12/90	3/12/90				3/12/90				3/12/90	3/12/90												
U.T.H.S.C. San Antonio																								
SAM	142			3/19/91							3/19/91	3/19/91												
SAD	141			3/19/91					3/19/91		3/19/91	3/19/91												
U.T.H.S.C. Houston																								
SPH	300	12/30/90		12/30/90					12/30/90			12/30/90			12/30/90			12/30/90	12/30/90			12/30/90	12/30/90	12/30/90
MSB	124	3/5/91		3/5/91	3/5/91						3/5/91	3/5/91			3/5/91									
Victoria ISD																								
SHS	126	6/4/91								6/4/91		6/4/91		6/4/91										
VHS	127	6/4/91								6/4/91	6/4/91	6/4/91		6/4/91										
UTMB Galveston																								
JSN	400	6/4/91							6/4/91		6/4/91	6/4/91			6/4/91									
CSB	401	6/18/91							6/18/91		6/18/91	6/18/91			6/18/91									
BSB	402	6/19/91							6/19/91		6/19/91	6/19/91			6/19/91									
MLB	403	6/19/91							6/19/91		6/19/91	6/19/91			6/19/91									
JSS	404	6/19/91							6/19/91		6/19/91	6/19/91			6/19/91									
Fort Worth ISD																								
SIM	128	9/10/91			9/10/91									9/10/91										
DMS	129	9/17/91			9/17/91									9/17/91										
Miscellaneous Locations																								
UTP	125	9/3/91					9/3/91					9/3/91												
TDH	130	2/15/91									2/15/91	2/15/91				2/15/91								
MDA	136	9/10/91					9/10/91		9/10/91	9/10/91	9/10/91	9/10/91		9/10/91	9/10/91		9/10/91							
UTD	137	8/29/91																						
COM	138	8/13/91																						
TAG	139	11/12/91									11/12/91	11/12/91		11/12/91										
DMC	143	11/12/91								11/12/91	11/12/91	11/12/91		11/12/91										
MCC	144	1/7/92								1/7/92														
WMH	145	1/16/92							1/16/92	1/16/92														
DCG	146	6/30/92		6/30/92					6/30/92	6/30/92	6/30/92	6/30/92		6/30/92										
SWT	149	1/14/92						1/14/92		1/14/92	1/14/92	1/14/92		1/14/92	1/14/92		1/14/92							
TST	150	6/23/92																						
MHR	151	7/14/92						7/14/92						7/14/92		7/14/92								
NHS	152	7/14/92	7/14/92		7/14/92					7/14/92				7/14/92										
CMS	153	7/14/92	7/14/92		7/14/92																			

Table 2: LoanSTAR Monitoring Start Date.

Retrofit Start Date

		Electric									Cooling		Heating					HVAC						
LS	LS	WBE	MCC	AHU	Lght	Elev	Spec	Cog	Pump	ChW	ChW	ChW	HW	NG	Con	FW	Ste	H/C	CD	RAir	RAir	Fan	SAir	SAir
Code	#	kW	kW	kW	kW	kW	kW	kW	kW	kW	Flow	Btu	Btu	CFT	Flow	Flow	Press	Temp	RH	Temp	RH	dP	Temp	RH
Texas A&M																								
ZEC	001	11/28/90	11/28/90	11/28/90			11/28/90				11/28/90	11/28/90	11/28/90					11/28/90	11/28/90	11/28/90	11/28/90	11/28/90	11/28/90	11/28/90
U. T Austin																								
EDB	100	5/30/91		5/30/91					5/30/91		5/30/91	5/30/91			5/30/91									
UTC	101	10/15/90		10/15/90					10/15/90		10/15/90	10/15/90			10/15/90									
PCL	102	10/23/90		10/23/90					10/23/90		10/23/90	10/23/90			10/23/90									
WAG	105	5/23/91		5/23/91							5/23/91	5/23/91			5/23/91									
WEL	106	6/1/91		6/1/91					6/1/91		6/1/91	6/1/91			6/1/91									
BUR	107	5/15/91		5/15/91					5/15/91		5/15/91	5/15/91			5/15/91									
NUR	108	4/15/91		4/15/91			4/15/91		4/15/91		4/15/91	4/15/91			4/15/91									
WIN	114	7/2/91										7/2/91			7/2/91									
STD	115	3/31/91										3/31/91			3/31/91									
PAI	116	6/1/91									6/1/91	6/1/91			6/1/91									
WCH	117	2/1/91									2/1/91	2/1/91			2/1/91									
GAR	118	1/29/91		1/29/91					1/29/91		1/29/91	1/29/91			1/29/91									
GEA	119	2/21/91		2/21/91					2/21/91		2/21/91	2/21/91			2/21/91									
U.T.Arlington																								
UNV	111	7/1/91		7/1/91							7/1/91	7/1/91			7/1/91									
BUS	112	7/12/91		7/12/91	7/12/91						7/12/91	7/12/91			7/12/91									
FNA	113	5/14/91		5/14/91			5/14/91				5/14/91	5/14/91			5/14/91									
State Capitol Complex																								
SHB	201	1		1					1	1		1		1	1	1		1	1	1	1			
SFA	202	1	1	1	1				1	1		1		1		1		1	1	1	1	1		
JHR	203	1		1	1	1			1			1			1									
JER	205	1								1														
INS	206	1	1									1												
INX	207	1	1							1														
ARC	208	1	1									1												
WBT	209	1		1		1						1												
LBJ	210	1		1	1				1			1												
JHW	211	1					1				1	1												
U.T.H.S.C. San Antonio																								
SAM	142			1							1	1												
SAD	141			1					1		1	1												
U.T.H.S.C. Houston																								
SPH	300	1		1					1			1			1			1	1			1	1	1
MSB	124	5/10/91		5/10/91	5/10/91						5/10/91	5/10/91			5/10/91									
Victoria ISD																								
SHS	126	1								1		1		1										
VHS	127	1								1	1	1		1										
UTMB Galveston																								
JSN	400	1							1		1	1			1									
CSB	401	1							1		1	1			1									
BSB	402	1							1		1	1			1									
MLB	403	1							1		1	1			1									
JSS	404	1							1		1	1			1									
Fort Worth ISD																								
SIM	128	11/23/91			11/23/91									11/23/91										
DMS	129	12/9/91			12/9/91									12/9/91										
Miscellaneous Locations																								
UTP	125	1					1					1												
TDH	130	9/1/91									9/1/91	9/1/91				9/1/91								
MDA	136	1					1		1	1	1	1		1	1		1							
UTD	137	1																						
COM	138	6/30/92																						
TAG	139	1									1	1		1										
DMC	143	1								1	1	1		1										
MCC	144	9/30/92								9/30/92														
WMH	145	4/30/92							4/30/92	4/30/92														
DCG	146	1		1					1	1	1	1		1										
SWT	149	10/31/92						10/31/92		10/31/92	10/31/92	10/31/92		10/31/92	10/31/92		10/31/92							
TST	150	10/31/92																						
MHR	151	1						1						1		1								
NHS	152	10/31/92	10/31/92		10/31/92					10/31/92				10/31/92										
CMS	153	10/31/92	10/31/91		10/31/92																			

Table 3: Retrofit Monitoring Start Date

Retrofit Completion Date

LS	LS	Electric									Cooling		Heating					HVAC						
		WBE	MCC	AHU	Lght	Elev	Spec	Cog	Pump	ChW	ChW	ChW	HW	NG	Con	FW	Ste	H/C	CD	RAir	RAir	Fan	SAir	SAir
Code	#	kW	kW	kW	kW	kW	kW	kW	kW	kW	Flow	Btu	Btu	CFT	Flow	Flow	Press	Temp	RH	Temp	RH	dP	Temp	RH
Texas A&M																								
ZEC	001	3/6/91	3/6/91	3/6/91			3/6/91				3/6/91	3/6/91	3/6/91					3/6/91	3/6/91	3/6/91	3/6/91	3/6/91	3/6/91	3/6/91
U. T Austin																								
EDB	100	7/3/91		7/3/91					7/3/91		7/3/91	7/3/91			7/3/91									
UTC	101	10/15/90		10/15/90					10/15/90		10/15/90	10/15/90			10/15/90									
PCL	102	12/7/90		12/7/90					12/7/90		12/7/90	12/7/90			12/7/90									
WAG	105	8/25/91		8/25/91							8/25/91	8/25/91			8/25/91									
WEL	106	6/1/91		6/1/91					6/1/91		6/1/91	6/1/91			6/1/91									
BUR	107	5/29/91		5/29/91					5/29/91		5/29/91	5/29/91			5/29/91									
NUR	108	4/16/91		4/16/91			4/16/91		4/16/91		4/16/91	4/16/91			4/16/91									
WIN	114	7/2/91										7/2/91			7/2/91									
STD	115	3/31/91										3/31/91			3/31/91									
PAI	116	3/1/92									3/1/92	3/1/92			3/1/92									
WCH	117	7/1/91									7/1/91	7/1/91			7/1/91									
GAR	118	5/1/91		5/1/91					5/1/91		5/1/91	5/1/91			5/1/91									
GEA	119	10/1/91		10/1/91					10/1/91		10/1/91	10/1/91			10/1/91									
U.T.Arlington																								
UNV	111	10/1/91		10/1/91							10/1/91	10/1/91			10/1/91									
BUS	112	8/1/91		8/1/91	8/1/91						8/1/91	8/1/91			8/1/91									
FNA	113	8/22/91		8/22/91			8/22/91				8/22/91	8/22/91			8/22/91									
State Capitol Complex																								
SHB	201	1		1					1	1		1		1	1	1		1	1	1	1			
SFA	202	1	1	1	1				1	1		1		1		1		1	1	1	1	1		
JHR	203	1		1	1	1			1			1			1									
JER	205	1								1														
INS	206	1	1									1												
INX	207	1	1							1														
ARC	208	1	1									1												
WBT	209	1		1		1						1												
LBJ	210	1		1	1				1			1												
JHW	211	1					1				1	1												
U.T.H.S.C. San Antonio																								
SAM	142			1							1	1												
SAD	141			1					1		1	1												
U.T.H.S.C. Houston																								
SPH	300	1		1					1			1			1			1	1			1	1	1
MSB	124	7/1/91		7/1/91	7/1/91						7/1/91	7/1/91			7/1/91									
Victoria ISD																								
SHS	126	8/15/91								8/15/91		8/15/91		8/15/91										
VHS	127	8/15/91								8/15/91	8/15/91	8/15/91		8/15/91										
UTMB Galveston																								
JSN	400	1							1		1	1			1									
CSB	401	1							1		1	1			1									
BSB	402	1							1		1	1			1									
MLB	403	1							1		1	1			1									
JSS	404	1							1		1	1			1									
Fort Worth ISD																								
SIM	128	11/23/91			11/23/91									11/23/91										
DMS	129	12/9/91			12/9/91									12/9/91										
Miscellaneous Locations																								
UTP	125	1					1					1												
TDH	130	3/16/92									3/16/92	3/16/92				3/16/92								
MDA	136	1					1		1	1	1	1		1	1		1							
UTD	137	1																						
COM	138	6/30/92																						
TAG	139	1									1	1		1										
DMC	143	1								1	1	1		1										
MCC	144	9/30/92								9/30/92														
WMH	145	4/30/92							4/30/92	4/30/92														
DCG	146	1		1					1	1	1	1		1										
SWT	149	10/31/92						10/31/92		10/31/92	10/31/92	10/31/92		10/31/92	10/31/92		10/31/92							
TST	150	10/31/92																						
MHR	151	1						1						1		1								
NHS	152	10/31/92	10/31/92		10/31/92																			
CMS	153	10/31/92	10/31/92		10/31/92																			

Table 4: Retrofit Monitoring Completion Date.

Types and Location of Weather Data Collected under the LoanSTAR program.

			LoanSTAR Sites					National Weather Service Sites								
# Sites	LS Code	LS #	DB Temp.	RH %	Solar Radiatio	Wind Speed	Total	# of Sites	LS Code	NWS Code	Hours er Day	Location	DB Temp.	Dew Point	Wind Speed	Total
Greater Bryan/College Station Area								1	810	CLL		College Station	1	1	1	3
								1	836	T46		South Brazos	1	1	1	3
	Texas A&M															
1	ZEC	001	1	1	1	1	4									
Greater Austin Area								1	806	AUS		Austin	1	1	1	3
	U. T. Austin															
1	EDB	100														
1	UTC	101														
1	PCL	102														
1	GAR	118														
1	GEA	119														
1	WAG	105														
1	WEL	106														
1	BUR	107														
1	NUR	108														
1	WIN	114														
1	STD	115														
1	PAI	116														
1	WCH	117														
	State Capitol Complex															
1	CPP	204														
1	SHB	201														
1	SFA	202	1	1	1	1	4									
1	JHR	203														
1	JER	205														
1	INS	206														
1	INX	207														
1	ARC	208														
1	WBT	209														
1	LBJ	210														
1	JHW	211														
	Other Austin Sites															
1	TDH	130														
1	MHR	151														
Greater Dallas/Forth Worth Area								1	814	DFW		DFW Airport	1	1	1	3
								1	813	DAL		Dallas Love Field	1	1	1	3
								1	819	FTW		Fort Worth	1	1	1	3
	U. T. Arlington															
1	UNV	111	1	1	1	1	4									
1	BUS	112														
1	FNA	113														
1	DCG	146														
	Fort Worth ISD															
1	SIM	128														
1	DMS	129														
	Other Dallas/Forth Worth Sites															
1	UTD	137														
1	COM	138														
Greater San Antonio Area								1	846	SSJ		San Antonio Stinson	1	1	1	3
								1	842	SAT		San Antonio	1	1	1	3
	U. T. H. S. C. San Antonio															
1	SAM	142														
1	SAD	141	1	1	1	1	4									
	Other San Antonio Sites															
1	SWT	149														
Greater Houston Area Sites								1	826	IAH		Houston Intercontinental	1	1	1	3
								1	824	HOU		Houston Hobby	1	1	1	3
	U. T. H. S. C. Houston															
1	SPH	300														
1	MSB	124	1	1	1	1	4									
	Other Houston Sites															
1	MDA	136														

Table 5: Type and Location of Weather Data Collected under the LoanSTAR Program.

Types and Location of Weather Data Collected under the LoanSTAR program.

# of Sites	LS Code	LS #	LoanSTAR Sites: DB Temp.	RH %	Solar Radiatio	Wind Speed	Total
Greater Galveston/Corpus Cristi Area							
U. T. M. B. Galveston							
1	MLB	403					
1	BSB	402					
1	CSB	401					
1	JSN	400					
1	JSS	404					
Other Galveston/Corpus Cristi Sites							
1	TAG	139	1	1	1	1	4
1	DMC	143					
Miscellaneous Locations							
Victoria ISD							
1	SHS	126					
1	VHS	127					
Midland Area							
1	MCC	144					
1	WMH	145					
Lufkin Area							
1	NHS	152					
1	CMS	153					
Other Locations							
1	UTP	125					
1	TST	150	1	1	1	1	4
56			7	7	7	7	28

# of Sites	LS Code	NWS Code	Hours er Day	National Weather Service Sites: Location	DB Temp.	Dew Point	Wind Speed	Total
1	822	GLS		Galveston	1	1	1	3
1	812	CRP		Corpus Cristi	1	1	1	3
1	850	VCT		Victoria	1	1	1	3
1	832	MAF		Midland	1	1	1	3
1	830	LFK		Lufkin	1	1	1	3
1	833	MFE		McAllen	1	1	1	3
1	825	HRL		Harlingen	1	1	1	3
				Other National Weather Service Sites				
				Texas Locations				
1	802	ABI		Abilene	1	1	1	3
1	804	ALI		Alice	1	1	1	3
1	805	AMA		Amarillo	1	1	1	3
1	807	BPT		Beaumont	1	1	1	3
1	808	BRO		Brownsville	1	1	1	3
1	876	BCE		Bryce Canyon	1	1	1	3
1	823	HFF		Canadian	1	1	1	3
1	809	CDS		Childress	1	1	1	3
1	811	COT		Cotulla	1	1	1	3
1	815	DHT		Dalhart	1	1	1	3
1	816	DRT		Del Rio	1	1	1	3
1	817	ELP		El Paso	1	1	1	3
1	818	FOQ		Freeport	1	1	1	3
1	820	GDP		Guadalupa Pass	1	1	1	3
1	828	JCT		Junction	1	1	1	3
1	831	LRD		Laredo	1	1	1	3
1	821	GGG		Longview	1	1	1	3
1	829	LBB		Lubbock	1	1	1	3
1	834	MRF		Marfa	1	1	1	3
1	835	MWL		Mineral Wells	1	1	1	3
1	838	PSX		Palacios	1	1	1	3
1	837	PRX		Paris	1	1	1	3
1	839	PVW		Plainview	1	1	1	3
1	840	RKP		Rockport	1	1	1	3
1	841	RPE		Sabine Pass	1	1	1	3
1	844	SJT		San Angelo	1	1	1	3
1	836	PO7		Sanderson	1	1	1	3
1	848	TPL		Temple	1	1	1	3
1	849	TYR		Tyler	1	1	1	3
1	803	ACT		Waco	1	1	1	3
1	845	SPS		Wichita Falls	1	1	1	3
1	827	INK		Wink	1	1	1	3
				Other States				
1	898	DCA		Washington D.C.	1	1	1	3
1	843	SHV		Shreveport, LA	1	1	1	3
1	875	BOS		Boston, MA	1	1	1	3
1	899	IAD		Dulles IAP, VA	1	1	1	3
53					53	53	53	159

Table 5: Continued...

Data Flow

A flow diagram of the data flow for the macro review of the sites is shown in Figure 3. It represents an overview of how the data was extracted from the UNIX data base and formatted into the spreadsheets which were used to create the plots for each site contained later in this report.

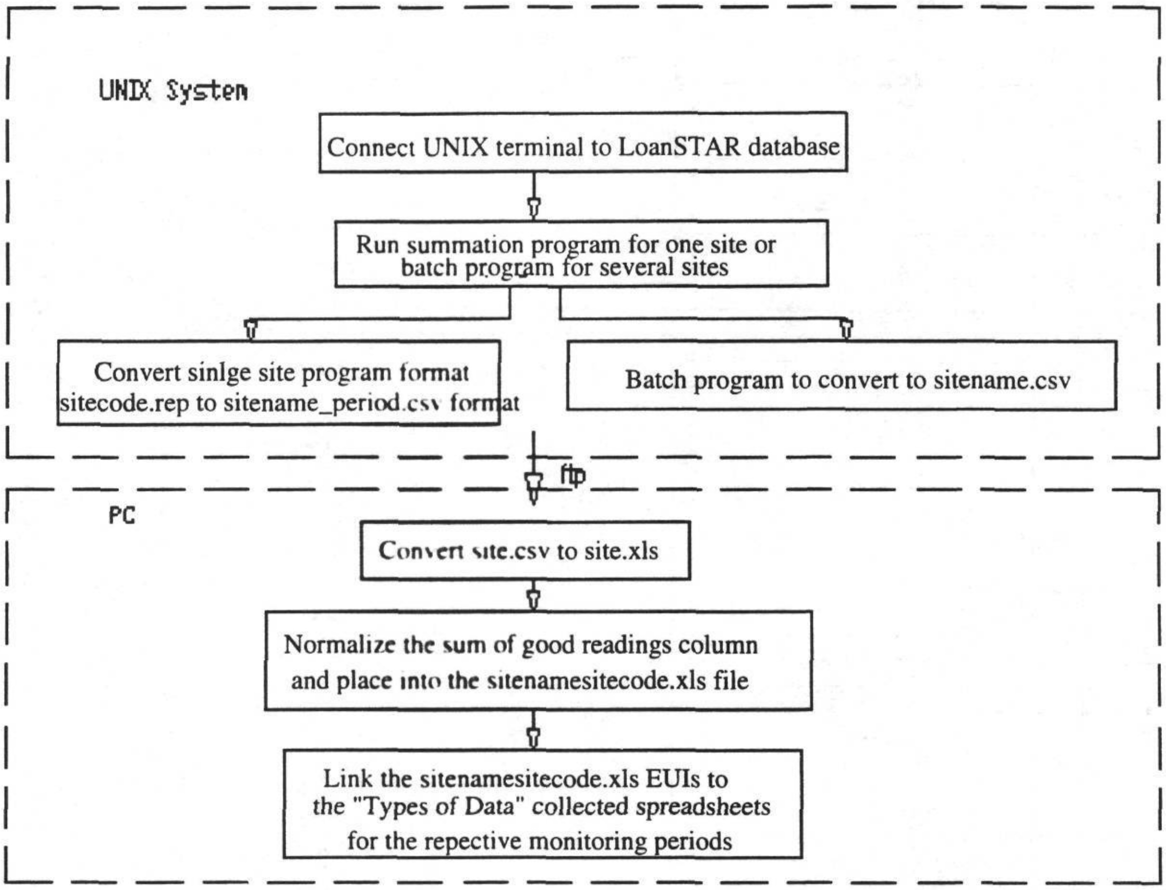


Figure 3: Data Flow

To explain the data flow, the Zachry Engineering Center data for the monitoring period of calendar year 1991 will be used as an example. The LoanSTAR sitename for the Zachry Engineering Center is ZEC and the sitecode is 001.

The next step for the "totals001.rep" file is to relocate and rename the file. This step was necessary in order to be able to distinguish this file, which contains 1991 data summary, from other file created from the Zachry data[13]. The file would be moved and renamed using the following command line: % mv totals001.rep /reports/zec_91.rep. This will move (UNIX move command is mv) file "totals001.rep" to subdirectory "reports" and rename that file "zec_91.rep". The "reports" directory was used to allow all of the outputs to be in one location when it becomes necessary to transfer the files to a personal computer. If the file was for a different monitoring period, the "_91" would be replaced by the new monitoring period code, i.e. "_ 91" for 1991, "_92" for 1992, "_pre" for pre-retrofit data, "_pst" for post-retrofit data, and "_tot" for total LoanSTAR monitored data. If future monitoring periods are determined to be of interest (i.e. 1993, summer 1992, winter 1993, etc.), create an unique one to three character alpha/numeric code to represent that period (i.e. "_93", "_s92", "_w93", etc.). Of course, the monitoring period code should correspond to the start date and end date used with the "totals" program. The general format for this file is *sitename_period*.rep where *sitename* represents the three letter LoanSTAR name for the site and *period* represents the monitoring period from which the data was extracted.

With all of the *sitename_period*.rep files in one location, in the :"reports" subdirectory, the next step is to convert the file format into a comma separated variable format or *.csv format. The *.csv format was necessary to allow the spreadsheet program to recognize each column of data as a unique entry into the spreadsheet, instead of as a character array in one column on the spreadsheet. An AWK language program called tocsv_vr.awk was used to perform this task. Tocsv_vr.awk is similar to other AWK programs which place a character (in this case an comma) at certain locations (i.e. where spaces exist between the data); however, this program accounts for the variable length description column that exists to describe each channel type. In addition,

[13]Running the program "totals" again, using a different start date and end date will overwrite any existing file named totals001.rep.

The first thing to do, of course, is to log into the LoanSTAR UNIX system and to go to the subdirectory containing the program routines and to access the LoanSTAR database, identified as the first step in the flow diagram. To obtain the 1991 data for Zachry, the following commands would be entered into the UNIX system: % totals 001 "1991-01-01 00" "1991-12-31 23". This will execute the program "totals" on site 001. A copy of the program "totals" is contained in the appendix. The output to "totals" is "totals001.rep" with "001" representing the site that was selected to be totaled. Therefore, to obtain data of site 100 the keystrokes used would be as follows: % totals 110 "start date" "end date". The start date and end date would be the "year(####)-month(##)-day(##) hour(##)" which corresponds to the monitoring period of interest. Figure 6 contains an example of the output of the "totals" program for site 001, 1991 monitoring period (the example from above).

ch_id	description	acp	first date	last date	# of possible readings	# of good readings	percent good	sum of good readings	# of bad readings	percent bad
ch0510	Main Service Leg #2 (kWh/h)	09	1991-01-01 00	1991-12-31 23	8760	8495	96.97	2767532.00	11	0.13
ch0511	Main Service Leg #3 (kWh/h)	10	1991-01-01 00	1991-12-31 23	8760	8495	96.97	2866928.50	11	0.13
ch0512	MCC #1 Leg #1 (kWh/h)	11	1991-01-01 00	1991-12-31 23	8760	8495	96.97	434577.28	11	0.13
ch0513	MCC #1 Leg #2 (kWh/h)	12	1991-01-01 00	1991-12-31 23	8760	8495	96.97	452734.31	11	0.13
ch0514	MCC #1 Leg #3 (kWh/h)	13	1991-01-01 00	1991-12-31 23	8760	8495	96.97	417070.78	11	0.13
ch0515	MCC #2 Leg #1 (kWh/h)	14	1991-01-01 00	1991-12-31 23	8760	8495	96.97	167930.97	11	0.13
ch0516	MCC #2 Leg #2 (kWh/h)	15	1991-01-01 00	1991-12-31 23	8760	8495	96.97	181235.64	11	0.13
ch0517	MCC #2 Leg #3 (kWh/h)	16	1991-01-01 00	1991-12-31 23	8760	8495	96.97	158423.95	11	0.13
ch0518	Crystal Palace #1 (kWh/h)	17	1991-01-01 00	1991-12-31 23	8760	8495	96.97	390463.97	11	0.13
ch0519	Crystal Palace #2 (kWh/h)	18	1991-01-01 00	1991-12-31 23	8760	8495	96.97	372478.69	11	0.13
ch0520	Crystal Palace #3 (kWh/h)	19	1991-01-01 00	1991-12-31 23	8760	8473	96.72	324406.03	11	0.13
ch0521	Main Service Leg #1 (kWh/h)	08	1991-01-01 00	1991-12-31 23	8760	8495	96.97	2677262.50	11	0.13
ch0522	AHU Fan Leg #1 (kWh/h)	21	1991-01-01 00	1991-12-31 23	8760	8457	96.54	36623.37	11	0.13
ch0523	AHU Fan Leg #2 (kwh/h)	22	1991-01-01 00	1991-12-31 23	8760	8372	95.57	34036.67	11	0.13
ch0524	AHU Fan Leg #3 (kWh/h)	23	1991-01-01 00	1991-12-31 23	8760	8495	96.97	82.18	11	0.13
ch0525	Rooftop Dry Bulb (F)	24	1991-01-01 00	1991-12-31 23	8760	8495	96.97	576920.69	11	0.13
ch0526	Rooftop Relative Hum. (%)	25	1991-01-01 00	1991-12-31 23	8760	8263	94.33	582656.75	11	0.13
ch0527	Rooftop Global Solar (W/m2)	26	1991-01-01 00	1991-12-31 23	8760	8383	95.70	1426984.88	9	0.10
ch0528	Rooftop Wind Speed (mph)	27	1991-01-01 00	1991-12-31 23	8760	6072	69.32	76603.21	10	0.11
ch0529	Whole Bldg. CW (100kBtu) bad meter	46	1991-01-01 00	1991-12-31 23	8760	8495	96.97	509774.00	11	0.13
ch0530	Whole Bldg. HW (100kBtu)	44	1991-01-01 00	1991-12-31 23	8760	8494	96.96	962.00	11	0.13
ch0531	Hot Deck Temperature (F)	30	1991-01-01 00	1991-12-31 23	8760	8458	96.55	760643.38	11	0.13
ch0532	Cold Deck Temperature (F)	31	1991-01-01 00	1991-12-31 23	8760	8315	94.92	450230.50	8	0.09
ch0533	Cold Deck Relative Humidity (%)	32	1991-01-01 00	1991-12-31 23	8760	8114	92.63	721680.62	11	0.13
ch0534	Mixed Air Temperature (F)	33	1991-01-01 00	1991-12-31 23	8760	8458	96.55	650029.56	11	0.13
ch0535	Mixed Air Relative Humdity (%)	34	1991-01-01 00	1991-12-31 23	8760	8495	96.97	390264.94	11	0.13
ch0536	Return Air Temperature (F)	35	1991-01-01 00	1991-12-31 23	8760	8451	96.47	638651.44	11	0.13
ch0537	Return Air Relative Humidity (%)	36	1991-01-01 00	1991-12-31 23	8760	8495	96.97	404987.28	11	0.13
ch0538	Air Flow Rate (SCFM)	37	1991-01-01 00	1991-12-31 23	8760	8319	94.97	43765140.00	10	0.11
ch0539	Pressure Drop Across the fan (in)	38	1991-01-01 00	1991-12-31 23	8760	8494	96.96	-28049.94	10	0.11
ch0540	Percent ON time Hot Water Pump1	39	1991-01-01 00	1991-12-31 23	8760	8495	96.97	0.00	11	0.13
ch0541	Percent ON time Hot Water Pump2	40	1991-01-01 00	1991-12-31 23	8760	8495	96.97	0.07	11	0.13
ch0542	Percent ON time Cold Water Pump1	41	1991-01-01 00	1991-12-31 23	8760	8495	96.97	4200.57	11	0.13
ch0543	Percent ON time Cold Water Pump2	42	1991-01-01 00	1991-12-31 23	8760	8495	96.97	1709.24	11	0.13
ch0544	Whole Bldg. HW flow gallons	43	1991-01-01 00	1991-12-31 23	8760	3874	44.22	2602680.00	4629	52.84
ch0545	Whole Bldg. HW kBtu	29	1991-01-01 00	1991-12-31 23	8760	2746	31.37	596744.00	5759	65.74
ch0546	Whole Bldg. CW consumption (100kBtu)	28	1991-01-01 00	1991-12-31 23	8760	2110	24.09	71013.10	6394	72.99
ch0547	Whole Bldg. CW flow gallons	45	1991-01-01 00	1991-12-31 23	8760	2256	25.75	8770776.00	6250	71.35
ch0908	AHU10 HW (kBtu)	47	1991-01-01 00	1991-12-31 23	8760	0	0.00	0.00	0	0.00
ch0909	AHU10 HW Flow (gal)	48	1991-01-01 00	1991-12-31 23	8760	0	0.00	0.00	0	0.00
ch0910	AHU10 ChW (kBtu)	49	1991-01-01 00	1991-12-31 23	8760	0	0.00	0.00	0	0.00
ch0911	AHU10 ChW (gal)	50	1991-01-01 00	1991-12-31 23	8760	0	0.00	0.00	0	0.00

Table 6: Example of a *sitename_period*.rep file using zec_91.rep.

some sites have commas in the description column (Zachry does not) which skewed the data by placing to many columns of data into the spreadsheet for that row of data. This resulted in a spreadsheet with columns of data that did not correspond to the columns of output from the "totals" program. Another AWK language program (stripcom.awk) was used to remove all commas prior to converting the tabulated data into the *.csv. A copy of both tocsv_vr.awk and stripcom.awk are contained in the appendix. The syntax used is as follows:

% cd reports
% gawk -f stripcom.awk *sitename_period*.rep > temp.out
% gawk -f tocsv_vr.awk temp.out > *sitename_period*.csv

The results for zec_91.csv is shown in Table 7. The zec_91.csv file is now ready to be transferred to a personal computer. The general format for these files is *sitename_period*.csv. It should be noted that the only difference between the data in Table 6 and the data in Table 7 is the column headings are removed from Table 7 as well as data is now separated by commas instead of spaces. Both tables represent UNIX files.

Because the summary information was required from more than one site and more than one monitoring period, the UNIX system procedure identified above was incorporated into a batch file and executed in the background of the UNIX system. The batch programs had the following format:

```
totals001 "start date" "end date"
mv totals001.rep /reports/zec_period.rep
totals100 "start date" "end date"
mv totals100.rep /reports/arc_period.rep
etc, etc, etc. for each site
cd reports
do
        name=`basename $file .rep`
        gawk -f stripcom.awk $file > temp.out
        gawk -f tocsv_vr.awk temp.out . $name.csv
        del temp.out
done
```

where the last few lines changes to the subdirectory "reports", which contains the *sitename_period*.rep files and the stripcom.awk and tocsv_vr.awk files, and converts all of the *sitename_period*.rep file to the *sitename_period*.csv format. For the 1991 monitoring period, the batch program is called data.91, similarly for 1992 the batch program is data.91, pre-retrofit period is data.pre, post-retrofit period is data.pst, and for the total LoanSTAR monitoring period the batch program is data.tot. For the batch programs data.pre, data.pst and data.tot, the start date and end date are the dates identified in Tables 2, 3 and 4 earlier in this report.

```
ch0510,Main Service Leg #2 (kWh/h),09,1991-01-01,00,1991-12-31,23,8760,8495,96.97,2767532.00,11,0.13
ch0511,Main Service Leg #3 (kWh/h),10,1991-01-01,00,1991-12-31,23,8760,8495,96.97,2866928.50,11,0.13
ch0512,MCC #1 Leg #1 (kWh/h),11,1991-01-01,00,1991-12-31,23,8760,8495,96.97,434577.28,11,0.13
ch0513,MCC #1 Leg #2 (kWh/h),12,1991-01-01,00,1991-12-31,23,8760,8495,96.97,452734.31,11,0.13
ch0514,MCC #1 Leg #3 (kWh/h),13,1991-01-01,00,1991-12-31,23,8760,8495,96.97,417070.78,11,0.13
ch0515,MCC #2 Leg #1 (kWh/h),14,1991-01-01,00,1991-12-31,23,8760,8495,96.97,167930.97,11,0.13
ch0516,MCC #2 Leg #2 (kWh/h),15,1991-01-01,00,1991-12-31,23,8760,8495,96.97,181235.84,11,0.13
ch0517,MCC #2 Leg #3 (kWh/h),16,1991-01-01,00,1991-12-31,23,8760,8495,96.97,158413.95,11,0.13
ch0518,Crystal Palace #1 (kWh/h),17,1991-01-01,00,1991-12-31,23,8760,8495,96.97,390463.97,11,0.13
ch0519,Crystal Palace #2 (kWh/h),18,1991-01-01,00,1991-12-31,23,8760,8495,96.97,372478.69,11,0.13
ch0520,Crystal Palace #3 (kWh/h),19,1991-01-01,00,1991-12-31,23,8760,8473,96.72,324406.03,11,0.13
ch0521,Main Service Leg #1 (kWh/h),08,1991-01-01,00,1991-12-31,23,8760,8495,96.97,2677262.50,11,0.13
ch0522,AHU Fan Leg #1 (kWh/h),21,1991-01-01,00,1991-12-31,23,8760,8457,96.54,36823.37,11,0.13
ch0523,AHU Fan Leg #2 (kwh/h),22,1991-01-01,00,1991-12-31,23,8760,8372,95.57,34036.87,11,0.13
ch0524,AHU Fan Leg #3 (kWh/h),23,1991-01-01,00,1991-12-31,23,8760,8495,96.97,82.18,11,0.13
ch0525,Rooftop Dry Bulb (F),24,1991-01-01,00,1991-12-31,23,8760,8495,96.97,578920.69,11,0.13
ch0526,Rooftop Relative Hum. (%),25,1991-01-01,00,1991-12-31,23,8760,8263,94.33,582656.75,11,0.13
ch0527,Rooftop Global Solar (W/m2),26,1991-01-01,00,1991-12-31,23,8760,8383,95.70,1426984.88,9,0.10
ch0528,Rooftop Wind Speed (mph),27,1991-01-01,00,1991-12-31,23,8760,6072,69.32,76603.21,10,0.11
ch0529,Whole Bldg. CW (100kBtu) bad meter,46,1991-01-01,00,1991-12-31,23,8760,8495,96.97,509774.00,11,0.13
ch0530,Whole Bldg. HW (100kBtu),44,1991-01-01,00,1991-12-31,23,8760,8494,96.96,962.00,11,0.13
ch0531,Hot Deck Temperature (F),30,1991-01-01,00,1991-12-31,23,8760,8458,96.55,760643.38,11,0.13
ch0532,Cold Deck Temperature (F),31,1991-01-01,00,1991-12-31,23,8760,8315,94.92,450230.50,8,0.09
ch0533,Cold Deck Relative Humidity (%),32,1991-01-01,00,1991-12-31,23,8760,8114,92.63,721680.62,11,0.13
ch0534,Mixed Air Temperature (F),33,1991-01-01,00,1991-12-31,23,8760,8458,96.55,650029.56,11,0.13
ch0535,Mixed Air Relative Humdity (%),34,1991-01-01,00,1991-12-31,23,8760,8495,96.97,390284.94,11,0.13
ch0536,Return Air Temperature (F),35,1991-01-01,00,1991-12-31,23,8760,8451,96.47,638851.44,11,0.13
ch0537,Return Air Relative Humidity (%),36,1991-01-01,00,1991-12-31,23,8760,8495,96.97,404987.28,11,0.13
ch0538,Air Flow Rate (SCFM),37,1991-01-01,00,1991-12-31,23,8760,8319,94.97,43765140.00,10,0.11
ch0539,Pressure Drop Across the fan (in),38,1991-01-01,00,1991-12-31,23,8760,8494,96.96,-28049.94,10,0.11
ch0540,Percent ON time Hot Water Pump1,39,1991-01-01,00,1991-12-31,23,8760,8495,96.97,0.00,11,0.13
ch0541,Percent ON time Hot Water Pump2,40,1991-01-01,00,1991-12-31,23,8760,8495,96.97,0.07,11,0.13
ch0542,Percent ON time Cold Water Pump1,41,1991-01-01,00,1991-12-31,23,8760,8495,96.97,4200.57,11,0.13
ch0543,Percent ON time Cold Water Pump2,42,1991-01-01,00,1991-12-31,23,8760,8495,96.97,1709.24,11,0.13
ch0544,Whole Bldg. HW flow gallons,43,1991-01-01,00,1991-12-31,23,8760,3874,44.22,2602680.00,4629,52.84
ch0545,Whole Bldg. HW kBtu,29,1991-01-01,00,1991-12-31,23,8760,2748,31.37,596744.00,5759,65.74
ch0546,Whole Bldg. CW consumption (100kBtu),28,1991-01-01,00,1991-12-31,23,8760,2110,24.09,71013.10,6394,72.99
ch0547,Whole Bldg. CW flow gallons,45,1991-01-01,00,1991-12-31,23,8760,2256,25.75,8770776.00,6250,71.35
ch0908,AHU10 HW (kBtu),47,1991-01-01,00,1991-12-31,23,8760,0,0.00,0.00,0,0.00
ch0909,AHU10 HW Flow (gal),48,1991-01-01,00,1991-12-31,23,8760,0,0.00,0.00,0,0.00
ch0910,AHU10 ChW (kBtu),49,1991-01-01,00,1991-12-31,23,8760,0,0.00,0.00,0,0.00
ch0911,AHU10 ChW (gal),50,1991-01-01,00,1991-12-31,23,8760,0,0.00,0.00,0,0.00
```

Table 7: Example of a *sitename_period*.csv file using zec_91.csc.

The end date for the total LoanSTAR monitoring period was chosen to be the 23rd hour of December 1992[14]. When a retrofit start date does not exist, the pre-retrofit and total period will be the same,;similarly, when no monitoring was performed prior to the retrofit completion date (as is the case for some sites) the post-retrofit and total periods will be the same. A note of warning, when the five batch files were combined and run together, the program took over 5 days to execute, therefore, care should be taken to ensure that the start date and end date correspond to the monitoring period of interest. Because the first two lines of the *sitename_period*.rep file contains character information and not data from the LoanSTAR database, these lines are removed by the program tocsv_vr.awk. Additionally, all calculations in the spreadsheet assume that these lines are no longer in the *sitename_period*.xls file. Leaving them in the file will cause errors to the *sitenamesitecode*.xls files described later in this report.

The *sitename_period*.csv file is now ready to be transferred to the PC. The "ftp" (file transfer protocol) data protocol system was used to transfer the files to a MS-DOS subdirectory I:\DATA_TYP\CSV*sitename_period*.csv. An Excel macro (five macros in total, one for each monitoring period used in this report) was written which will open the *sitename_period*.csv file and save the file as a *sitename_period*.xls in the I:\DATA_TYP\DATA*SITENAME*\ subdirectory. For the Zachry Engineering Center's 1991 monitoring data, the macro will do the following: opens I:\DATA_TYP\CSC\zec_91.csv and saves the file as I:\DATA_TYP\ZEC\zec_91.xls. The five macros are called 91.xlm, 92.xlm, pre.xlm, pst.xlm, and tot.xlm. To create a new macro for another monitoring period, i.e. 1993 period, copy tot.xlm as 93.xlm, open the 93.xlm macro file and select the "Replace..." command from the "Formula" pulldown. Replace "_tot" with "_93". Next, rename the function command

---

[14]Because of the length of time it took to develop the procedure described in this report and the requirement for LoanSTAR to periodically "clean" or review the data, this report only contains plots of data to January 1, 1993. No 1993 data or later is used in any of the plots in this report but the procedure, now complete, could be used to get an index of the 1993 data for each site, or any other monitoring period of interest.

"ToConvertTotalData" to "ToConvert93Data" by selecting the "Define Name..." command from the "Formula" pulldown. Save the new 93.xlm file.

To execute a macro, open the macro from the I:\DATA_TYP\ subdirectory, select the "Run... " command from the "Macro" pulldown. The "Run..." will list all macro functions available for execution. If the function "ToConvert*Period*Data" is not available for the *period* you wish to convert to *sitename_period*.xls format, go back and ensure that you have opened the macro for that *period*. The macros, when executed, will pop up an input screen instructing you to enter the three letter code for the side you wish to convert (ZEC for Zachry) or enter "all" if all sites are to be converted to the *sitename_period*.xls format or enter "no" if no more sites are to be converted (which will exit the macro). A copy of the tot.xlm macro is contained in the appendix. The other macro's are identical, just replace every "_tot" with "*_period*" of interest. Table 8 is an example for the zec_91.csv file after it was converted to zec_91.xls.

It is again noted that the only difference between Table 7 and Table 8 is that Table 7 is a UNIX file with data separated with commas and Table 8 is an Excel spreadsheet with the data in individual cells. The data in Table 8 is then linked to the cells in Table 9 as described later in this report. Linked Excel files will automatically update the information in the "receiving file" whenever the data in the "source" file is changed.

Normalizing the data

The data from each of the *sitename_perio*d.xls files are normalized in a *sitenamesitecode*.xls file. The term "normalized" refers to accounting for the different building conditioned areas (square feet) for the sites being monitored and the different time frame for each monitoring period. Table 9 is the example for the Zachry data.

ch0510	Main Service Leg #2 (kWh/h)	9	1991-01-01	0	1991-12-31	23	8760	8495	96.97	2767532	11	0.13
ch0511	Main Service Leg #3 (kWh/h)	10	1991-01-01	0	1991-12-31	23	8760	8495	96.97	2866929	11	0.13
ch0512	MCC #1 Leg #1 (kWh/h)	11	1991-01-01	0	1991-12-31	23	8760	8495	96.97	434577.3	11	0.13
ch0513	MCC #1 Leg #2 (kWh/h)	12	1991-01-01	0	1991-12-31	23	8760	8495	96.97	452734.3	11	0.13
ch0514	MCC #1 Leg #3 (kWh/h)	13	1991-01-01	0	1991-12-31	23	8760	8495	96.97	417070.8	11	0.13
ch0515	MCC #2 Leg #1 (kWh/h)	14	1991-01-01	0	1991-12-31	23	8760	8495	96.97	167931	11	0.13
ch0516	MCC #2 Leg #2 (kWh/h)	15	1991-01-01	0	1991-12-31	23	8760	8495	96.97	181235.8	11	0.13
ch0517	MCC #2 Leg #3 (kWh/h)	16	1991-01-01	0	1991-12-31	23	8760	8495	96.97	158414	11	0.13
ch0518	Crystal Palace #1 (kWh/h)	17	1991-01-01	0	1991-12-31	23	8760	8495	96.97	390464	11	0.13
ch0519	Crystal Palace #2 (kWh/h)	18	1991-01-01	0	1991-12-31	23	8760	8495	96.97	372478.7	11	0.13
ch0520	Crystal Palace #3 (kWh/h)	19	1991-01-01	0	1991-12-31	23	8760	8473	96.72	324406	11	0.13
ch0521	Main Service Leg #1 (kWh/h)	8	1991-01-01	0	1991-12-31	23	8760	8495	96.97	2677263	11	0.13
ch0522	AHU Fan Leg #1 (kWh/h)	21	1991-01-01	0	1991-12-31	23	8760	8457	96.54	36823.37	11	0.13
ch0523	AHU Fan Leg #2 (kwh/h)	22	1991-01-01	0	1991-12-31	23	8760	8372	95.57	34036.87	11	0.13
ch0524	AHU Fan Leg #3 (kWh/h)	23	1991-01-01	0	1991-12-31	23	8760	8495	96.97	82.18	11	0.13
ch0525	Rooftop Dry Bulb (F)	24	1991-01-01	0	1991-12-31	23	8760	8495	96.97	578920.7	11	0.13
ch0526	Rooftop Relative Hum. (%)	25	1991-01-01	0	1991-12-31	23	8760	8263	94.33	582656.8	11	0.13
ch0527	Rooftop Global Solar (W/m2)	26	1991-01-01	0	1991-12-31	23	8760	8383	95.7	1426985	9	0.1
ch0528	Rooftop Wind Speed (mph)	27	1991-01-01	0	1991-12-31	23	8760	6072	69.32	76603.21	10	0.11
ch0529	Whole Bldg. CW (100kBtu) bad meter	46	1991-01-01	0	1991-12-31	23	8760	8495	96.97	509774	11	0.13
ch0530	Whole Bldg. HW (100kBtu)	44	1991-01-01	0	1991-12-31	23	8760	8494	96.96	962	11	0.13
ch0531	Hot Deck Temperature (F)	30	1991-01-01	0	1991-12-31	23	8760	8458	96.55	760643.4	11	0.13
ch0532	Cold Deck Temperature (F)	31	1991-01-01	0	1991-12-31	23	8760	8315	94.92	450230.5	8	0.09
ch0533	Cold Deck Relative Humidity (%)	32	1991-01-01	0	1991-12-31	23	8760	8114	92.63	721680.6	11	0.13
ch0534	Mixed Air Temperature (F)	33	1991-01-01	0	1991-12-31	23	8760	8458	96.55	650029.6	11	0.13
ch0535	Mixed Air Relative Humdity (%)	34	1991-01-01	0	1991-12-31	23	8760	8495	96.97	390284.9	11	0.13
ch0536	Return Air Temperature (F)	35	1991-01-01	0	1991-12-31	23	8760	8451	96.47	638851.4	11	0.13
ch0537	Return Air Relative Humidity (%)	36	1991-01-01	0	1991-12-31	23	8760	8495	96.97	404987.3	11	0.13
ch0538	Air Flow Rate (SCFM)	37	1991-01-01	0	1991-12-31	23	8760	8319	94.97	43765140	10	0.11
ch0539	Pressure Drop Across the fan (in)	38	1991-01-01	0	1991-12-31	23	8760	8494	96.96	-28049.9	10	0.11
ch0540	Percent ON time Hot Water Pump1	39	1991-01-01	0	1991-12-31	23	8760	8495	96.97	0	11	0.13
ch0541	Percent ON time Hot Water Pump2	40	1991-01-01	0	1991-12-31	23	8760	8495	96.97	0.07	11	0.13
ch0542	Percent ON time Cold Water Pump1	41	1991-01-01	0	1991-12-31	23	8760	8495	96.97	4200.57	11	0.13
ch0543	Percent ON time Cold Water Pump2	42	1991-01-01	0	1991-12-31	23	8760	8495	96.97	1709.24	11	0.13
ch0544	Whole Bldg. HW flow gallons	43	1991-01-01	0	1991-12-31	23	8760	3874	44.22	2602680	4629	52.8
ch0545	Whole Bldg. HW kBtu	29	1991-01-01	0	1991-12-31	23	8760	2748	31.37	596744	5759	65.7
ch0546	Whole Bldg. CW consumption (100kBtu)	28	1991-01-01	0	1991-12-31	23	8760	2110	24.09	71013.1	6394	73
ch0547	Whole Bldg. CW flow gallons	45	1991-01-01	0	1991-12-31	23	8760	2256	25.75	8770776	6250	71.4
ch0908	AHU10 HW (kBtu)	47	1991-01-01	0	1991-12-31	23	8760	0	0	0	0	0
ch0909	AHU10 HW Flow (gal)	48	1991-01-01	0	1991-12-31	23	8760	0	0	0	0	0
ch0910	AHU10 ChW (kBtu)	49	1991-01-01	0	1991-12-31	23	8760	0	0	0	0	0
ch0911	AHU10 ChW (gal)	50	1991-01-01	0	1991-12-31	23	8760	0	0	0	0	0

Table 8: Example of a *sitename_period*.xls file

The *sitenamesitecode*.xls files[15] contain the sitename in the upper left block, followed by the building's conditioned area in the second block. The horizontal rows give EUIs for the monitoring periods which

[15]The exception to this format is "WIN & STD" and "PAI & WCH" which are being monitored on a single data logger. These sites are contained in win114.xls (for WIN & STD) and pai116.xls (for PAI & WCH) with the same monitoring periods across the top with the vertical entries containing WIN data types listed first followed by STD

ZEC	324000							
		PRE	POST	TOTAL	CY91	91 AECR	CY92	92 AECR
WB Elect	W/SF	3.43	2.93	3.12	3.02	3.01	2.93	2.95
MCC Elect	W/SF	1.14	0.58	0.79	0.68		0.57	
AHU Elect	W/SF	0.06	0.02	0.03	0.03		0.02	
Cray Computer	W/SF	0.36	0.40	0.38	0.40		0.40	
Other Elect	W/SF	1.92	1.95	1.95	1.94		1.97	
ChW Flow	Gal/hr-SF	0.002	0.001	0.004	0.012		0.001	
ChW Energy	Btu/hr-SF	18.44	11.27	13.91	10.39	10.57	11.57	11.84
Heating Energy(ch0530)	Btu/hr-SF	0.01	0.16	0.11	0.03	2.84	0.26	0.98
Heating Energy(ch0545)	Btu/hr-SF	0.04	1.03	0.59	0.67	2.84	1.00	0.98

Table 9: Example of a *Sitenamesitecode*.xls file using zec001.xls.

are included in this report (including the published indexes in the 1991 and 1992 AECR report[16], when available) while the vertical columns give the types of data being collected for the site. For an example of how the *sitename_period*.xls data is normalized into the *sitenamesitecode*.xls file, the Zachry Engineering Center's whole building electric (WB Elect) for the calendar year 91 monitoring period would be calculated as follows:

$$= (K1 \div I1 + K2 \div I2 + K12 \div I12) \times 1000 \text{ W/kW} \div \text{building square foot}$$

$$= (2767532.00 \text{ kWh} \div 8495 \text{ hours} + 2866928.50 \text{ kWh} \div 8495 \text{ hours} + 2677262.50 \text{ kWh} \div 8495 \text{ hours}) \times 1000 \text{ W/kW} \div 324{,}000 \text{ ft}^2$$

$$= 3.02 \text{ W/ft}^2$$

where K1 refers to the K^{th} column, 1^{st} row from the zec_91.xls file, I1 refers to the I^{th} column, 1^{st} row from the zec_91.xls file and so on. The building's conditioned area is obtained from the B^{th} column, 2^{nd} row from the zec001.xls file (as noted earlier). Similar equations exist for the other data types in the CY91 column, each pulling the appropriate values from the zec_91.xls file

date types, similarly for PAI and WCH. For sites with multiple data loggers (GAR, GEA, MSB, MDA, and SWT) there is only one *sitenamesitecode*.xls summary file but the monitoring periods will have multiple *sitename_period*.xls files corresponding to the number of data loggers being used on that site. The multiple *sitename_period*.xls files are accounted for in the equations used to calculate the normalized indexes in the *sitenamesitecode*.xls file.

[16]The indexes used in the AECR are kWh/ft^2-yr for electricity, Btu/ft^2-yr for chilled water and Btu/ft^2-yr for heating. The AECR numbers were converted to W/ft^2, Btu/ft^2 and Btu/ft^2 respectively.

into the zec001.xls file. For the other monitoring periods, the identical equation is used, except that the equation pulls the appropriate values from the zec_*period*.xls corresponding to the *period* being calculated in the zec001.xls column, i.e. the PRE column in Table 9 will utilities data from the zec_pre.xls file. The *sitenamesitecode*.xls files are used to create the plots of the EUIs versus monitoring period for each site contained in the next section of this report.

Finally, the data from each of the *sitenamesitecode*.xls files are linked to a summary spreadsheet for each monitoring period. Each column of data is linked to it's respective *period*.xls file. The CY91 column is linked to the 91.xls file, CY92 column is linked to the 92.xls, the PRE column is linked to the pre.xls file, and so on. The format for the *period*.xls is identical to the format of Table 1, the Types of Data Collected, except the 1's (denoting that site has that type of data being monitored) are replaced with the EUI calculated in the *sitenamesitecode*.xls files. Tables 10 through 14 contain the Summary EUIs for the pre-retrofit, post-retrofit, total, 1991, and 1992 monitoring periods. Tables 8 through 12 were used to create the summary plots by monitoring period and by data types comparing the EUI for each site in the LoanSTAR program

Example Data Plots for a LoanSTAR Site

The following pages contain the Energy Utilization Index (EUI) versus several different monitoring periods: pre-retrofit monitoring period, post-retrofit monitoring period, total LoanSTAR monitoring period, calendar year 1991 monitoring period and a calendar year 1992 monitoring period. The primary plots for each site are a Whole Building Electric (WBE) plot, a Chilled Water Flow (CWF) plot, a Chilled Water Energy (CWE) plot, and a Heating Energy (HE) plot.

Column #	LS Code	LS #	WB Elect W/SF	MCC Elect W/SF	AHU Elect W/SF	Electric Lights W/SF	Elevator Elect W/SF	Special Elect W/SF	Cogeneration Elect W/SF	Pumps Elect W/SF	ChW Elect W/SF	Other Elect W/SF	Cooling ChW Flow Gal/hr-SF	ChW Energy Btu/hr-SF	Heating HW Energy Btu/hr-SF	NG Energy Btu/hr-SF	Condensate Flow Btu/hr-SF	Feedwater Flow Btu/hr/SF
	Texas A&M																	
1	ZEC	001	3.43	1.14	0.06			0.36				1.92	0.002	18.44	0.01			
	U. T Austin																	
2	EDB	100	1.83		0.96					0.13		0.74	0.12	11.37			6.63	
3	UTC	101	#DIV/0!		#DIV/0!					#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			#DIV/0!	
4	PCL	102	0.00		0.75					0.00		-0.75	0.11	11.96			5.21	
5	WAG	105	2.53		0.76							1.78	0.20	40.91			5.37	
6	WEL	106	1.76		0.81					0.12		0.82	0.14	12.84			7.60	
7	BUR	107	1.22		0.87					0.20		0.15	0.10	9.90			7.46	
8	NUR	108	1.88		0.86			0.53		0.14		0.87	0.10	9.60			9.92	
9	WIN	114	1.57											21.84			14.91	
10	STD	115	0.33										0.06	5.95			4.27	
11	PAI	116	0.88										0.16	13.13			8.09	
12	WCH	117	1.00										0.19	13.38			11.31	
13	GAR	118	#DIV/0!		#DIV/0!					#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			#DIV/0!	
14	GEA	119	#DIV/0!		#DIV/0!					#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			#DIV/0!	
	U.T.Arlington																	
15	UNV	111	1.84		0.75							1.09	0.27	7.77			1.16	
16	BUS	112	2.07		0.62	0.37						1.08	0.39	8.19			3.61	
17	FNA	113	2.02		0.87			0.001				1.15	0.28	10.60			4.67	
	State Capitol Complex																	
18	SHB	201	N/A		N/A					N/A	N/A			N/A		N/A	N/A	
19	SFA	202	2.89							N/A	N/A	N/A		0.48		0.14		N/A
20	JHR	203	4.32		0.46	0.40	0.05			0.17		3.25		10.68				
21	JER	205	5.31								1.33	3.98						
22	INS	206	2.91	0.71								2.19		12.15				
23	INX	207	1.55	0.22							0.36	0.97						
24	ARC	208	1.56	0.81								0.76		10.33				
25	WBT	209	1.85		0.03		0.02					1.80		0.57				
26	LBJ	210	5.11		0.22	0.13				0.20		4.56		0.49				
27	JHW	211	4.45										0.40	13.78				
	U.T.H.S.C. San Antonio																	
28	SAM	142			0.14								0.10	9.92				
29	SAD	141			0.22					0.08			0.12	15.04				
	U.T.H.S.C. Houston																	
30	SPH	300	2.32		1.16					0.54		0.62	0.14	24.34			25.14	
31	MSB	124	N/A		N/A	N/A							N/A	N/A			N/A	
	Victoria ISD																	
32	SHS	126	0.81								0.10	0.71		1.08		1.91		
33	VHS	127	0.99								0.03		0.06	1.58		1.08		
	UTMB Galveston																	
34	JSN	400	7.59							0.41		7.19	0.72	63.75			N/A (IN COUNTS)	
35	CSB	401	3.93							0.15		3.78	0.22	23.81			N/A (IN COUNTS)	
36	BSB	402	3.53							0.26		3.26	0.11	35.20			N/A (IN COUNTS)	
37	MLB	403	2.65							0.09		2.56	0.24	25.63			N/A (IN COUNTS)	
38	JSS	404	2.65							0.18		2.48	0.18	31.50			N/A (IN COUNTS)	
	Fort Worth ISD																	
39	SIM	128	1.73			0.65						1.08				1.73		
40	DMS	129	2.12			0.64						1.48				3.25		
	Miscellaneous Locations																	
41	UTP	125	2.64					0.98						10.58				
42	TDH	130	2.80										0.54	16.82				7.08
43	MDA	136	N/A					N/A		N/A	N/A		N/A	N/A		N/A	N/A	
44	UTD	137	1.87															
45	COM	138	3.97															
46	TAG	139	2.33					0.81				1.51	0.21	6.99		37.64		
47	DMC	143	2.85								0.83	2.02	0.42	13.55		10.10		
48	MCC	144	2.40								0.30	2.10						
49	WMH	145	4.09							0.11	1.10	2.89						
50	DCG	146	2.56		0.23					0.18	0.62	1.54	0.24	9.79		5.77		
51	SWT	149	12.46						11.48		0.75		0.17	3.92			0.02	
52	TST	150	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
53	MHR	151	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
54	NHS	152	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
55	CMS	153	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															

Table 10: Summary of EUIs for Pre-Retrofit Period.

EUI FOR POST RETROFIT MONITORING PERIOD

						Electric							Cooling			Heating		
Column	LS	LS	WB Elect	MCC Elect	AHU Elect	Lights	Elevator Elect	Special Elect	Cogeneration Elect	Pumps Elect	ChW Elect	Other Elect	ChW Flow	ChW Energy	HW Energy	NG Energy	Condensate Flow	Feedwater Flow
#	Code	#	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	Gal/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr/SF
	Texas A&M																	
1	ZEC	001	2.93	0.58	0.02			0.40				1.95	0.001	11.27	0.16			
	U. T Austin																	
2	EDB	100	0.89		0.26					0.02		0.60	0.06	6.47			3.28	
3	UTC	101	1.08		0.31					0.02		0.76	0.03	4.44			2.50	
4	PCL	102	1.97		0.25					0.02		1.70	0.13	8.69			3.27	
5	WAG	105	2.16		0.33							1.83	0.16	10.06			2.05	
6	WEL	106	2.51		0.85					0.10		1.56	0.24	19.58			6.95	
7	BUR	107	1.06		0.36					0.06		0.65	0.08	7.29			3.77	
8	NUR	108	1.05		0.28			0.80		0.01		0.76	0.14	8.14			6.09	
9	WIN	114	1.56											13.51			5.66	
10	STD	115	0.45										0.13	8.08			2.21	
11	PAI	116	2.13										0.23	14.04			5.44	
12	WCH	117	0.97										0.08	7.26			4.50	
13	GAR	118	0.67		0.20					0.03		0.44	0.08	5.11			0.80	
14	GEA	119	1.09		0.26					0.04		0.79	0.11	8.50			3.40	
	U.T.Arlington																	
15	UNV	111	1.49		0.47							1.02	0.15	6.88			1.52	
16	BUS	112	1.89		0.46	0.36						1.07	0.47	8.76			2.67	
17	FNA	113	1.76		0.47			0.002				1.29	0.28	10.47			4.40	
	State Capitol Complex																	
18	SHB	201	N/A		N/A					N/A	N/A			N/A		N/A	N/A	
19	SFA	202	#DIV/0!							N/A	N/A	N/A		#DIV/0!		#DIV/0!		N/A
20	JHR	203	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			#DIV/0!		#DIV/0!		#DIV/0!				
21	JER	205	#DIV/0!								#DIV/0!	#DIV/0!						
22	INS	206	#DIV/0!	#DIV/0!								#DIV/0!		#DIV/0!				
23	INX	207	#DIV/0!	#DIV/0!							#DIV/0!	#DIV/0!						
24	ARC	208	#DIV/0!	#DIV/0!								#DIV/0!		#DIV/0!				
25	WBT	209	#DIV/0!		#DIV/0!		#DIV/0!					#DIV/0!		#DIV/0!				
26	LBJ	210	#DIV/0!		#DIV/0!	#DIV/0!				#DIV/0!		#DIV/0!		#DIV/0!				
27	JHW	211	#DIV/0!										#DIV/0!	#DIV/0!				
	U.T.H.S.C. San Antonio																	
28	SAM	142			#DIV/0!								#DIV/0!	#DIV/0!				
29	SAD	141			#DIV/0!					#DIV/0!			#DIV/0!	#DIV/0!				
	U.T.H.S.C. Houston																	
30	SPH	300	#DIV/0!		#DIV/0!					#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			#DIV/0!	
31	MSB	124	N/A		N/A	N/A							N/A	N/A			N/A	
	Victoria ISD																	
32	SHS	126	0.84								0.10	0.75		1.17		1.91		
33	VHS	127	1.01								0.04		0.06	1.62		1.09		
	UTMB Galveston																	
34	JSN	400	#DIV/0!							#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			N/A (IN COUNTS)	
35	CSB	401	#DIV/0!							#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			N/A (IN COUNTS)	
36	BSB	402	#DIV/0!							#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			N/A (IN COUNTS)	
37	MLB	403	#DIV/0!							#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			N/A (IN COUNTS)	
38	JSS	404	#DIV/0!							#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!			N/A (IN COUNTS)	
	Fort Worth ISD																	
39	SIM	128	1.31			0.38						0.92				2.53		
40	DMS	129	1.91			0.40						1.51				2.42		
	Miscellaneous Locations																	
41	UTP	125	#DIV/0!					#DIV/0!						#DIV/0!				
42	TDH	130	2.58										0.21	10.00				7.78
43	MDA	136	N/A					N/A		N/A	N/A		N/A	N/A		N/A	N/A	
44	UTD	137	#DIV/0!															
45	COM	138	3.31															
46	TAG	139	#DIV/0!					#DIV/0!				#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!		
47	DMC	143	#DIV/0!								#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!		
48	MCC	144	1.80								0.11	1.69						
49	WMH	145	4.54							0.12	1.56	2.85						
50	DCG	146	#DIV/0!		#DIV/0!					#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!		
51	SWT	149	9.21						9.21		#DIV/0!		0.09	1.90			0.00	
52	TST	150	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
53	MHR	151	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
54	NHS	152	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
55	CMS	153	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															

Table 11: Summary EUIs for Post-Retrofit Monitoring Period.

			Electric										Cooling		Heating			
Column	LS	LS	WB Elect	MCC Elect	AHU Elect	Lights	Elevator Elect	Special Elect	Cogeneration Elect	Pumps Elect	ChW Elect	Other Elect	ChW Flow	ChW Energy	HW Energy	NG Energy	Condensate Flow	Feedwater Flow
#	Code	#	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	Gal/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr/SF
	Texas A&M																	
1	ZEC	001	3.12	0.79	0.03			0.38				1.95	0.004	13.91	0.11			
	U. T Austin																	
2	EDB	100	1.08		0.46					0.06		0.56	0.08	7.77			4.12	
3	UTC	101	1.08		0.31					0.02		0.76	0.03	4.44			2.50	
4	PCL	102	1.94		0.26					0.02		1.66	0.12	8.64			3.40	
5	WAG	105	2.27		0.46							1.81	0.16	19.69			2.74	
6	WEL	106	2.29		0.84					0.11		1.34	0.21	17.58			7.17	
7	BUR	107	1.11		0.49					0.10		0.53	0.09	8.16			4.66	
8	NUR	108	1.25		0.42			0.74		0.04		0.79	0.12	7.75			7.01	
9	WIN	114	1.56											16.28			8.61	
10	STD	115	0.41										0.11	7.64			2.88	
11	PAI	116	1.88										0.22	13.58			7.23	
12	WCH	117	1.02										0.13	11.06			7.85	
13	GAR	118	0.67		0.20					0.03		0.44	0.06	3.73			0.80	
14	GEA	119	1.09		0.26					0.04		0.79	0.11	8.50			3.42	
	U.T.Arlington																	
15	UNV	111	1.62		0.57							1.04	0.16	6.49			1.25	
16	BUS	112	1.93		0.51	0.36						1.06	0.39	7.56			2.79	
17	FNA	113	1.84		0.58			0.001				1.26	0.28	11.73			4.10	
	State Capitol Complex																	
18	SHB	201	N/A		N/A					N/A	N/A			N/A		N/A	N/A	
19	SFA	202	2.89							N/A	N/A	N/A		0.48		0.14		N/A
20	JHR	203	4.32		0.46	0.40	0.05			0.17		3.25		10.68				
21	JER	205	5.31								1.33	3.98						
22	INS	206	2.91	0.71								2.19		12.15				
23	INX	207	1.55	0.22							0.36	0.97						
24	ARC	208	1.56	0.81								0.76		10.33				
25	WBT	209	1.85		0.03		0.02					1.80		0.57				
26	LBJ	210	5.11		0.22	0.13				0.20		4.56		0.49				
27	JHW	211	4.45										0.40	13.78				
	U.T.H.S.C. San Antonio																	
28	SAM	142			0.14								0.10	9.92				
29	SAD	141			0.22					0.08			0.12	15.04				
	U.T.H.S.C. Houston																	
30	SPH	300	2.18		1.16					0.54		0.48	0.14	24.34			25.14	
31	MSB	124	N/A		N/A	N/A							N/A	N/A			N/A	
	Victoria ISD																	
32	SHS	126	0.81								0.10	0.71		2.84		1.91		
33	VHS	127	0.99								0.03		0.05	1.33		1.08		
	UTMB Galveston																	
34	JSN	400	7.59							0.41		7.19	0.46	87.20			N/A (IN COUNTS)	
35	CSB	401	3.93							0.15		3.78	0.13	21.15			N/A (IN COUNTS)	
36	BSB	402	3.53							0.26		3.26	0.11	35.20			N/A (IN COUNTS)	
37	MLB	403	2.65							0.09		2.56	0.16	17.05			N/A (IN COUNTS)	
38	JSS	404	2.65							0.18		2.48	0.16	25.51			N/A (IN COUNTS)	
	Fort Worth ISD																	
39	SIM	128	1.37			0.43						0.95				2.40		
40	DMS	129	1.95			0.45						1.51				2.57		
	Miscellaneous Locations																	
41	UTP	125	2.64					0.98						10.58				
42	TDH	130	2.67										0.33	12.29				8.05
43	MDA	136	N/A					N/A		N/A	N/A		N/A	N/A		N/A	N/A	
44	UTD	137	1.87															
45	COM	138	3.85															
46	TAG	139	2.32					0.81				1.51	0.21	6.99		26.40		
47	DMC	143	2.49								0.83	1.65	0.38	12.55		10.10		
48	MCC	144	2.24								0.25	1.99						
49	WMH	145	4.40							0.12	1.42	2.86						
50	DCG	146	2.56		0.22					0.18	0.62	1.54	0.24	9.78		5.77		
51	SWT	149	12.06						11.08		0.75		0.17	3.92			0.02	
52	TST	150	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
53	MHR	151	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
54	NHS	152	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
55	CMS	153	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															

Table 12: Summary EUIs for Total LoanSTAR Monitoring Period.

Column	LS	LS	Electric										Cooling		Heating			
			WB Elect	MCC Elect	AHU Elect	Lights	Elevator Elect	Special Elect	Cogeneration Elect	Pumps Elect	ChW Elect	Other Elect	ChW Flow	ChW Energy	HW Energy	NG Energy	Condensate Flow	Feedwater Flow
#	Code	#	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	Gal/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr/SF
	Texas A&M																	
1	ZEC	001	3.12	0.79	0.03			0.38				1.95	0.004	13.91	0.11			
	U. T Austin																	
2	EDB	100	1.08		0.46					0.06		0.56	0.08	7.77			4.12	
3	UTC	101	1.08		0.31					0.02		0.76	0.03	4.44			2.50	
4	PCL	102	1.94		0.26					0.02		1.66	0.12	8.64			3.40	
5	WAG	105	2.27		0.46							1.81	0.16	19.69			2.74	
6	WEL	106	2.29		0.84					0.11		1.34	0.21	17.58			7.17	
7	BUR	107	1.11		0.49					0.10		0.53	0.09	8.16			4.66	
8	NUR	108	1.25		0.42			0.74		0.04		0.79	0.12	7.75			7.01	
9	WIN	114	1.56											16.28			8.61	
10	STD	115	0.41										0.11	7.64			2.88	
11	PAI	116	1.88										0.22	13.58			7.23	
12	WCH	117	1.02										0.13	11.06			7.85	
13	GAR	118	0.67		0.20					0.03		0.44	0.06	3.73			0.80	
14	GEA	119	1.09		0.26					0.04		0.79	0.11	8.50			3.42	
	U.T.Arlington																	
15	UNV	111	1.62		0.57							1.04	0.16	6.49			1.25	
16	BUS	112	1.93		0.51	0.36						1.06	0.39	7.56			2.79	
17	FNA	113	1.84		0.58			0.001				1.26	0.28	11.73			4.10	
	State Capitol Complex																	
18	SHB	201	N/A		N/A					N/A	N/A			N/A		N/A	N/A	
19	SFA	202	2.89							N/A	N/A	N/A		0.48		0.14		N/A
20	JHR	203	4.32		0.46	0.40	0.05			0.17		3.25		10.68				
21	JER	205	5.31								1.33	3.98						
22	INS	206	2.91	0.71								2.19		12.15				
23	INX	207	1.55	0.22							0.36	0.97						
24	ARC	208	1.56	0.81								0.76		10.33				
25	WBT	209	1.85		0.03		0.02					1.80		0.57				
26	LBJ	210	5.11		0.22	0.13				0.20		4.56		0.49				
27	JHW	211	4.45										0.40	13.78				
	U.T.H.S.C. San Antonio																	
28	SAM	142			0.14								0.10	9.92				
29	SAD	141			0.22					0.08			0.12	15.04				
	U.T.H.S.C. Houston																	
30	SPH	300	2.18		1.16					0.54		0.48	0.14	24.34			25.14	
31	MSB	124	N/A		N/A	N/A							N/A	N/A			N/A	
	Victoria ISD																	
32	SHS	126	0.81								0.10	0.71		2.84		1.91		
33	VHS	127	0.99								0.03		0.05	1.33		1.08		
	UTMB Galveston																	
34	JSN	400	7.59							0.41		7.19	0.46	87.20			N/A (IN COUNTS)	
35	CSB	401	3.93							0.15		3.78	0.13	21.15			N/A (IN COUNTS)	
36	BSB	402	3.53							0.26		3.26	0.11	35.20			N/A (IN COUNTS)	
37	MLB	403	2.65							0.09		2.56	0.16	17.05			N/A (IN COUNTS)	
38	JSS	404	2.65							0.18		2.48	0.16	25.51			N/A (IN COUNTS)	
	Fort Worth ISD																	
39	SIM	128	1.37			0.43						0.95				2.40		
40	DMS	129	1.95			0.45						1.51				2.57		
	Miscellaneous Locations																	
41	UTP	125	2.64					0.98						10.58				
42	TDH	130	2.67										0.33	12.29				8.05
43	MDA	136	N/A					N/A		N/A	N/A		N/A	N/A		N/A	N/A	
44	UTD	137	1.87															
45	COM	138	3.85															
46	TAG	139	2.32					0.81				1.51	0.21	6.99		26.40		
47	DMC	143	2.49								0.83	1.65	0.38	12.55		10.10		
48	MCC	144	2.24								0.25	1.99						
49	WMH	145	4.40							0.12	1.42	2.86						
50	DCG	146	2.56		0.22					0.18	0.62	1.54	0.24	9.78		5.77		
51	SWT	149	8.47						8.03		0.56		0.25	5.55			0.00	
52	TST	150	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
53	MHR	151	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
54	NHS	152	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
55	CMS	153	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															

Table 13: Summary EUIs for CY91 Monitoring Period.

EUI FOR CALENDER YEAR 1992 MONITORING PERIOD

Column	LS	LS	Electric										Cooling		Heating			
Column	LS	LS	WB Elect	MCC Elect	AHU Elect	Lights	Elevator Elect	Special Elect	Cogeneration Elect	Pumps Elect	ChW Elect	Other Elect	ChW Flow	ChW Energy	HW Energy	NG Energy	Condensate Flow	Feedwater Flow
#	Code	#	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	W/SF	Gal/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr-SF	Btu/hr/SF
	Texas A&M																	
1	ZEC	001	2.93	0.57	0.02			0.40				1.97	0.001	11.57	0.26			
	U. T Austin																	
2	EDB	100	0.86		0.25					0.01		0.60	0.05	6.17			3.79	
3	UTC	101	1.09		0.30					0.02		0.78	0.03	5.14			2.29	
4	PCL	102	1.93		0.25					0.01		1.67	0.12	8.15			2.56	
5	WAG	105	2.14		0.35							1.79	0.15	9.97			1.90	
6	WEL	106	2.41		0.88					0.08		1.45	0.20	16.82			7.05	
7	BUR	107	1.04		0.35					0.05		0.64	0.08	7.24			4.17	
8	NUR	108	0.99		0.27			0.83		0.01		0.71	0.15	7.45			7.32	
9	WIN	114	1.56											12.25			5.64	
10	STD	115	0.47										0.18	8.56			2.22	
11	PAI	116	2.16										0.23	13.20			6.26	
12	WCH	117	0.98										0.08	7.25			5.33	
13	GAR	118	0.64		0.18					0.03		0.42	0.09	5.18			0.82	
14	GEA	119	1.07		0.24					0.04		0.78	0.11	8.81			2.41	
	U.T.Arlington																	
15	UNV	111	1.49		0.48							1.01	0.16	7.31			1.46	
16	BUS	112	1.90		0.46	0.36						1.07	0.47	9.59			2.65	
17	FNA	113	1.75		0.49			0.002				1.25	0.28	10.40			4.30	
	State Capitol Complex																	
18	SHB	201	N/A		N/A					N/A	N/A			N/A		N/A	N/A	
19	SFA	202	0.00		0.00	0.00				N/A	N/A	N/A		#NAME?		#NAME?		N/A
20	JHR	203	4.24		0.47	0.38	0.04			0.17		3.18		16.92				
21	JER	205	5.30								1.33	3.97						
22	INS	206	2.91	0.72								2.19		12.33				
23	INX	207	1.59	0.23							0.38	0.98						
24	ARC	208	1.59	0.82								0.76		10.48				
25	WBT	209	1.89		0.03		0.02					1.84		#NAME?				
26	LBJ	210	4.87		0.22	0.13				0.20		4.32		#NAME?				
27	JHW	211	4.13										0.43	13.57				
	U.T.H.S.C. San Antonio																	
28	SAM	142			0.14								0.09	8.18				
29	SAD	141			0.22					0.07			0.10	9.67				
	U.T.H.S.C. Houston																	
30	SPH	300	2.47		1.05					0.52		0.90	0.14	16.79			13.30	
31	MSB	124	N/A		N/A	N/A							N/A	N/A			N/A	
	Victoria ISD																	
32	SHS	126	0.82								0.10	0.72		0.50		1.75		
33	VHS	127	0.95								0.04		0.05	1.32		1.00		
	UTMB Galveston																	
34	JSN	400	7.60							0.33		7.27	0.88	69.95			N/A (IN COUNTS)	
35	CSB	401	3.94							0.13		3.81	0.22	23.81			N/A (IN COUNTS)	
36	BSB	402	3.12							0.09		3.02	0.18	11.55			N/A (IN COUNTS)	
37	MLB	403	2.65							0.07		2.58	0.24	25.63			N/A (IN COUNTS)	
38	JSS	404	2.67							0.14		2.52	0.21	24.53			N/A (IN COUNTS)	
	Fort Worth ISD																	
39	SIM	128	1.36			0.39						0.97				2.30		
40	DMS	129	1.96			0.45						1.51				2.29		
	Miscellaneous Locations																	
41	UTP	125	2.65					1.00						10.89				
42	TDH	130	2.58										0.21	10.00				7.78
43	MDA	136	N/A					N/A		N/A	N/A		N/A	N/A		N/A	N/A	
44	UTD	137	1.87															
45	COM	138	3.65															
46	TAG	139	2.33					0.81				1.53	0.22	7.08		23.32		
47	DMC	143	2.47								0.86	1.61	0.42	13.71		10.01		
48	MCC	144	2.24								0.25	1.99						
49	WMH	145	4.40							0.12	1.42	2.86						
50	DCG	146	2.56		0.22					0.18	0.62	1.54	0.24	9.78		5.77		
51	SWT	149	11.92						10.94		0.72		0.17	3.89			0.02	
52	TST	150	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
53	MHR	151	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
54	NHS	152	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															
55	CMS	153	NO DATA AVAILABLE PRIOR TO DEC 31, 1992															

Table 14: Summary EUIs for CY92 Monitoring Period.

The miscellaneous plots for each site represent special submetering being performed on that site as part of a Level 2 or Level 3 monitoring plan. These additional plots will include one or more of following: a Motor Control Center Electrical (MCC) plot, an Air Handler Unit Electrical (AHU) plot, a Measured Lighting Electrical plot, an Elevator Electrical plot, Pumps Electrical plot, a Chiller Electrical plot, or an Other Electrical plot.

The submetering of the HVAC systems will not produce meaningful data when normalized (i.e. temperature, relative humidity, etc. are not cumulative in nature like electricity usage) and are not included in any of the plots in this report. The data from the HVAC submeters can be used in other types of plots (time series, box and whiskers, etc.) and are used in other LoanSTAR applications.

The miscellaneous plot usually does not represent the entire submetered category but is used to indicate how a particular retrofit or all the retrofits affects the submetered category, i.e. AHU electrical may only measure one set of AHUs in the building not all of the AHUs in the building or Measure Lighting may only be measuring the lighting load of one floor of a multiple story building. In this manner, the trends for the category can be reviewed without the expense of monitoring all of the circuits in the building that measure, say lighting (often it is impossible to separate the circuits for say, only lighting, only AHU, etc.). The Other Electrical plots represent the WBE minus all other submetered categories. This provides a rough estimate of the trends for the building's lights and receptacle or motor control centers when these categories are not measured directly.

For the Zachry Engineering Center's data in Table 9, the whole building electric plot is shown in Figure 4. The data being plotted is the "WB Elect" line in Table 9.

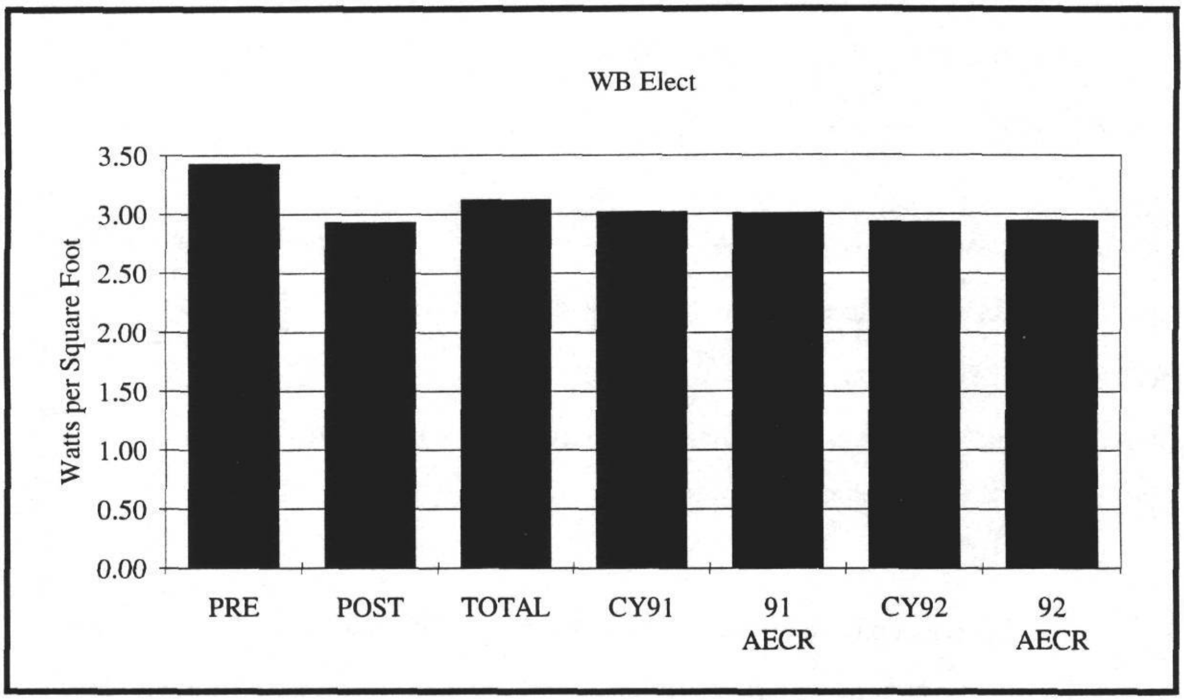


Figure 4: Whole Building Electric Plot for ZEC

Figure 4 shows that the Zachry Engineering Center has a lower post-retrofit electrical energy consumption when compared to the pre-retrofit period. Also the calendar year 1991 and 1992 shows a slight decrease in the EUI for those years. The higher 1991 EUI can be accounted for by the fact that the retrofit completion date was not until March 1991. Similarly, Figure 5 is the chilled water energy consumption plot for the data in Table 9 and Figure 6 is the chilled water flow measurement data for Table 9. Figures 5 and 6 are good examples of where either a metering error might exist for the

Zachry Engineering Center or a potential energy conservation retrofit project could be persued. Because the chilled water energy flow rate (Btu/hr) is equal to the product of the chilled water flow rate (lb/hr) times the specific heat of water (≈ 1 Btu/lb-°F) times the temperature differences (°F) of the chilled water, the chilled water flow can be predicted based on a set operating temperature difference for the chilled water plant.

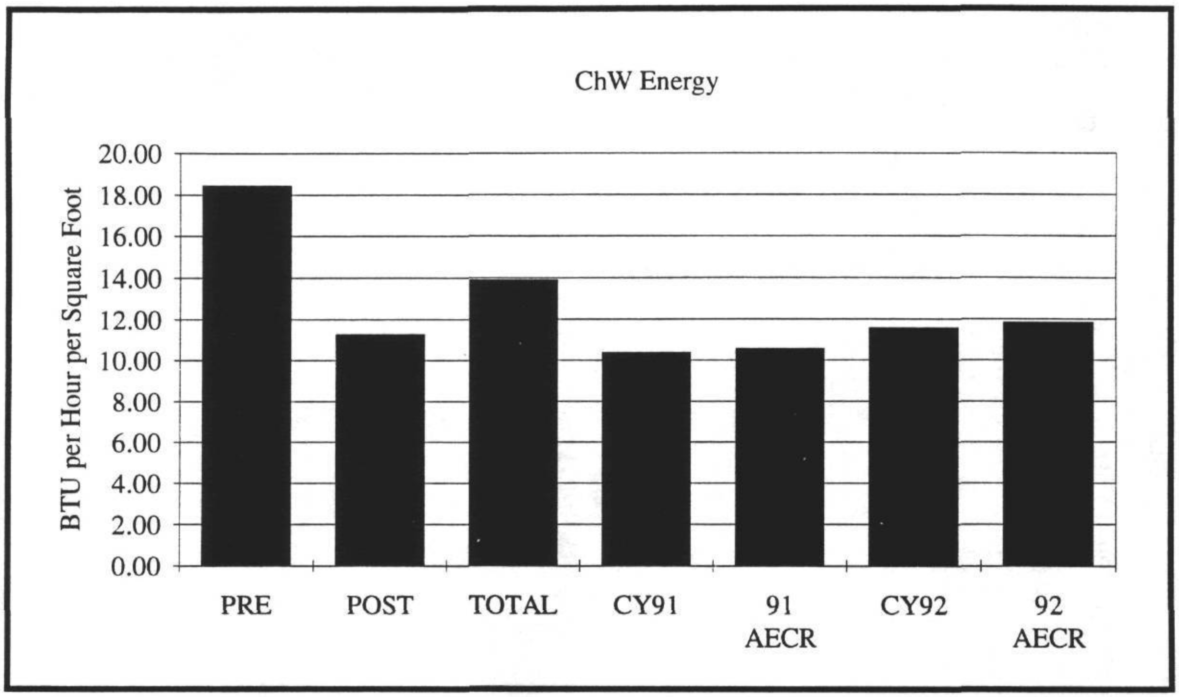


Figure 5: Chilled Water Energy Consumption for ZEC

For a 10°F temperature rise in the chilled water plant and using the average chilled water energy consumption of 14.0 Btu/hr-ft² (from the TOTAL monitoring period in Figure 5), the chilled water flow measurement[17] in Figure 6 should be on the order of

[17] 14.0 Btu/hr-ft² ÷ 1.0 Btu/lb-°F ÷ 10 °F ÷ 8.34 lb/gal = 0.17 gal/hr-ft².

magnitude of 0.17 gal/hr-ft^2. The measured quantities in Figure 6 are low by a factor of 40 or more. This would indicate that the chilled water system was operating with a 420°F temperature difference[18] in the chilled water plant. This in an indication of a metering error or scaling problem which needs to be investigated by the LoanSTAR staff. Had the chilled water flow measurement been high when compared to the chilled water energy consumption (assuming metering error is first check and/or corrected), it would indicate that the chilled water plant is operating at a temperature difference lower than 10°F and would be a candidate for an energy conservation retrofit or operation & maintenance correction.

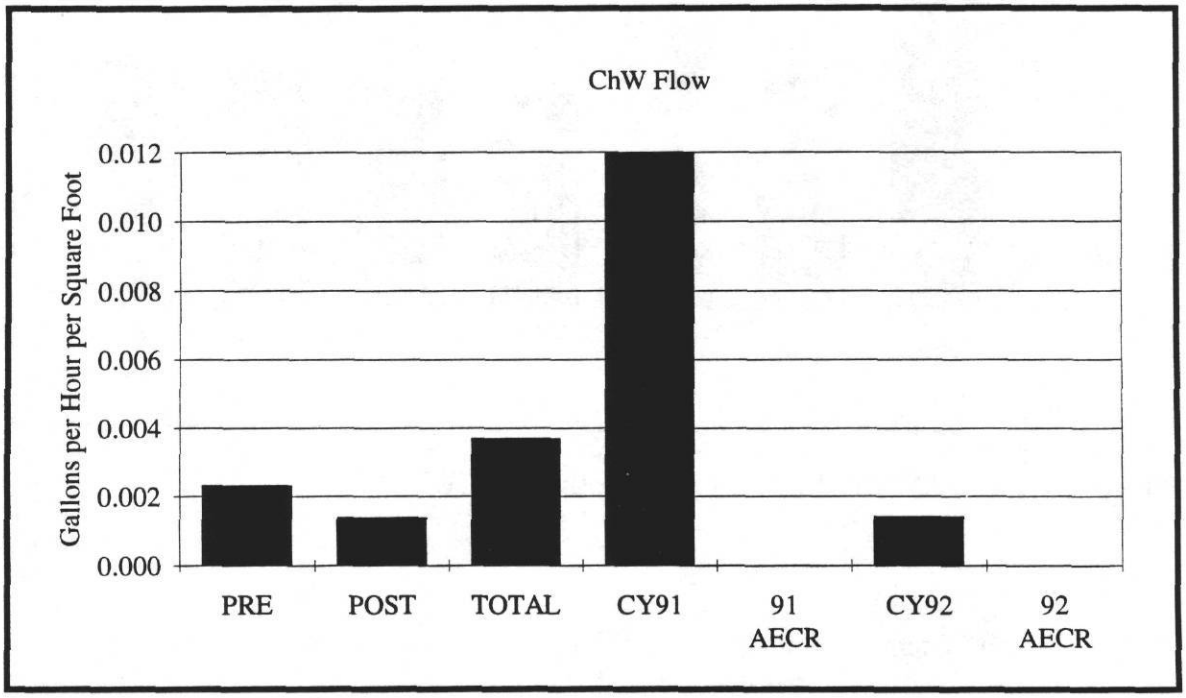


Figure 6: Chilled Water Flow for ZEC.

[18] 14.0 Btu/hr-ft^2 ÷ 1.0 Btu/lb-°F ÷ 0.004 gal/hr-ft^2 ÷ 8.34 lb/gal = 420 °F.

Finally, Figure 7 shows the heating energy plots for the data in Table 9. Because the Zachry Engineering Center has two hot water flow meters in parallel, both channels of data have been plotted together, side by side.

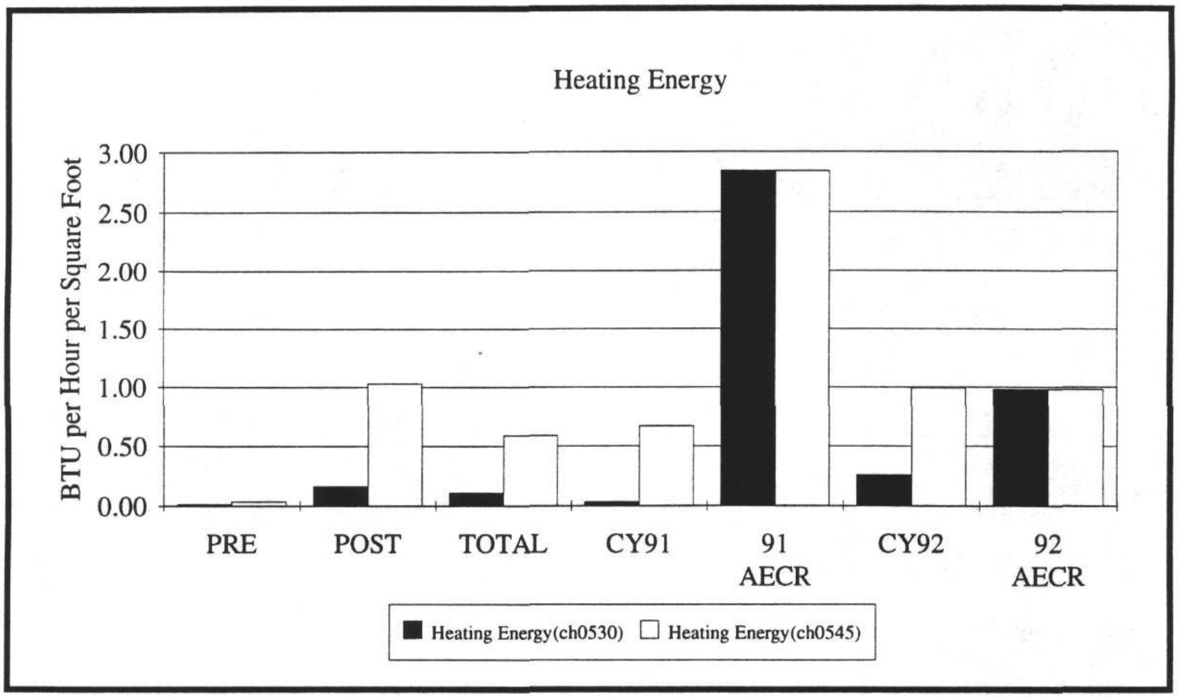


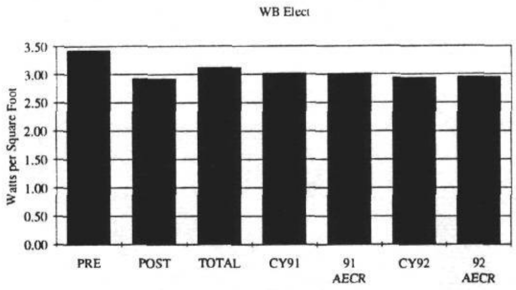
Figure 7: Heating Energy Consumption for ZEC.

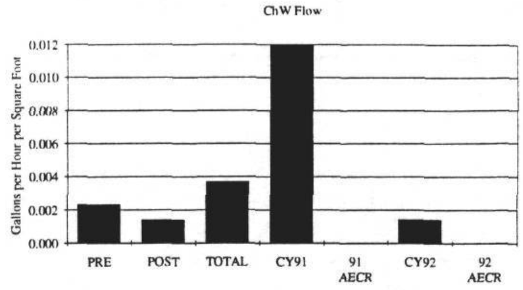
Figure 7 is a prime example of a possible metering problem with the data or possibly an incorrect scaling factor is being reported for the site. In any case, this plot requires further investigation on the part of the LoanSTAR staff.

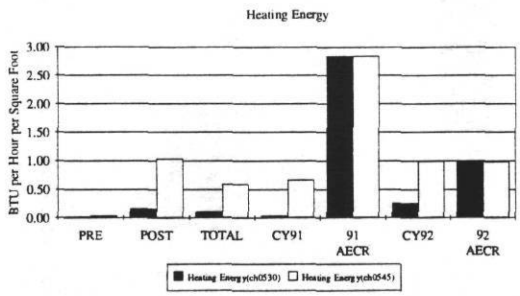
Data Plots for all LoanSTAR Sites

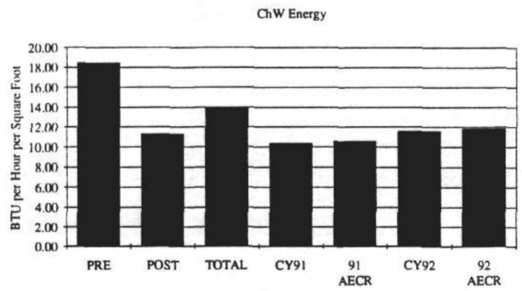
The following pages contains the energy utilization index plots for all of the LoanSTAR sites which had monitored data as of 1 January 1993.

Zachry Engineering Center
ZEC - 001









Zachry Engineering Center
Texas A & M University
College Station, Texas

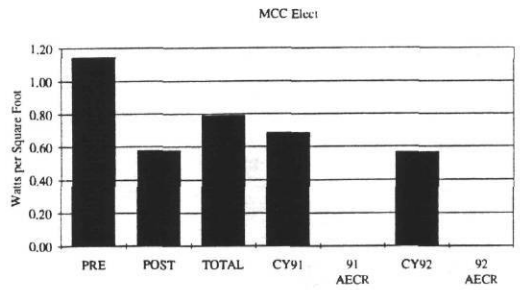
Size: 324,400 square feet.
Construction: Cement block walls, single pane windows with built-in-place vertical blinds are 22 % of total wall area, flat roof. Erected in 1973.
Lighting: Fluorescent.
Utilization: Classrooms, offices, labs, computer facitities, and clean rooms for Solid State Electronics.

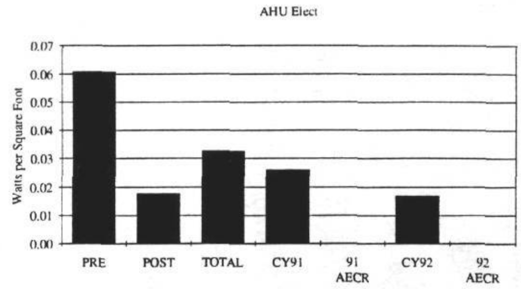
LoanSTAR Monitoring Start Date: May 31 1989.
Retrofit Start Date: November 28 1990.
Retrofit Completion Date: March 6 1991.

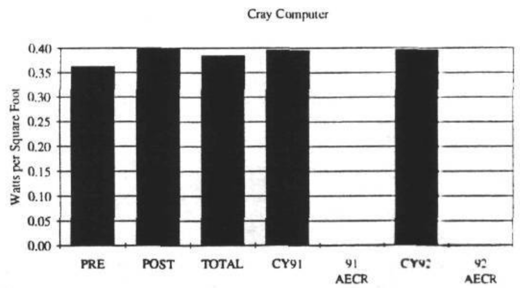
Retrofit Information:
- Control modifications to the dual duct HVAC system,
- Variable volume dual duct HVAC system,
- EMCS system to control HVAC system.
- Retrofit Costs/ Loan Amount: $1,331.660

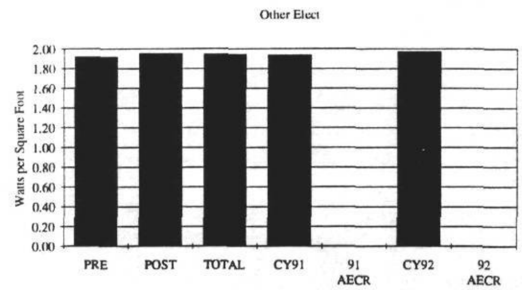
Utilities Unit Costs: $0.02788/kWh, $4.67/MMBtu (CW), and $4.74/MMBtu (HW). Heating is provided by hot water circulation.

Miscellaneous plots for the Zachary Engineering Center:

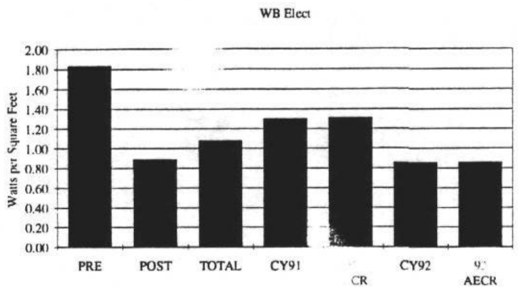


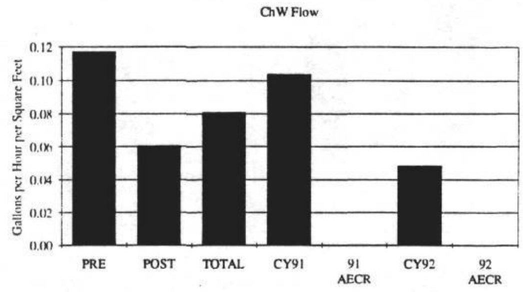


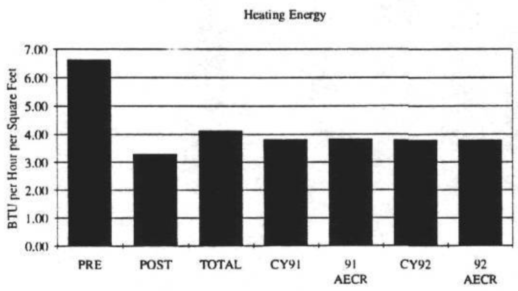


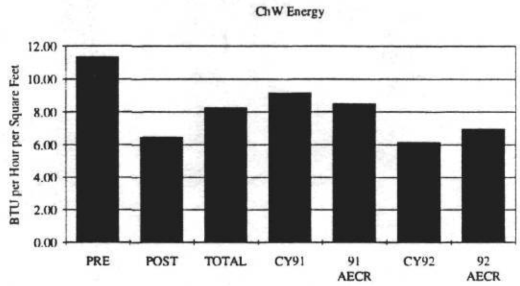


Education Building
EDB - 100









Education Building
University of Texas
Austin, Texas 78713

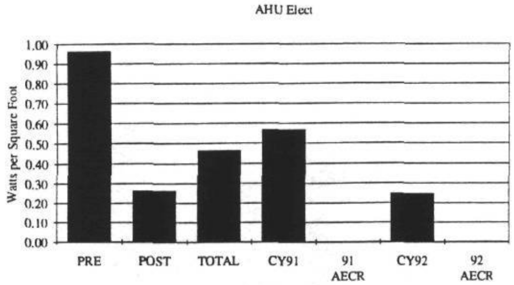
Size: 251,161 square feet
Construction: Face brick on block walls, single pain tinted glass windows are 30% of wall area, flat roof. Erected in 1976.
Lighting: Primarily fluorescent.
Utilization: Classrooms and administrative offices.

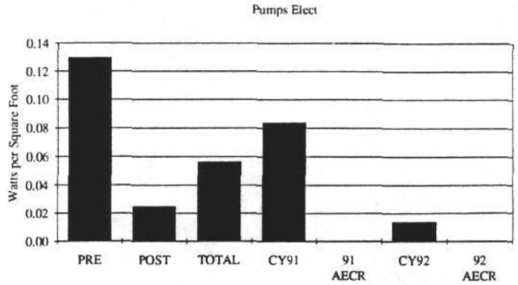
LoanSTAR Monitoring Start Date: October 13, 1990.
Retrofit Start Date: May 30, 1991.
Retrofit Completion Date: July 3, 1991.

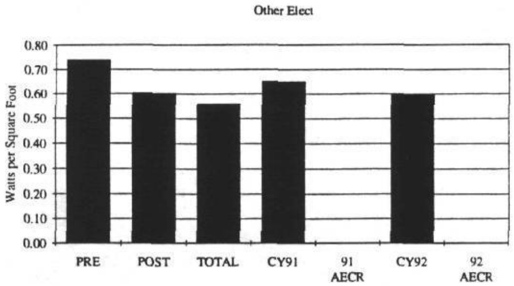
Retrofit Information:
- Variable air volume HVAC systems,
- Variable speed pumps,
- Replacement of incandescent lighting with fluorescent lighting.
- Retrofit Costs/Loan Amount: $636,968

Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

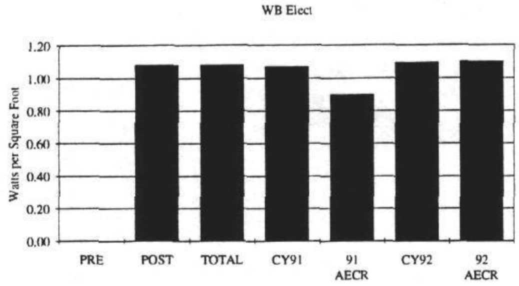
Miscellaneous plots for the Education Building:

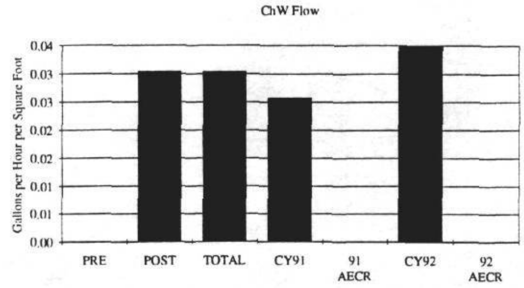


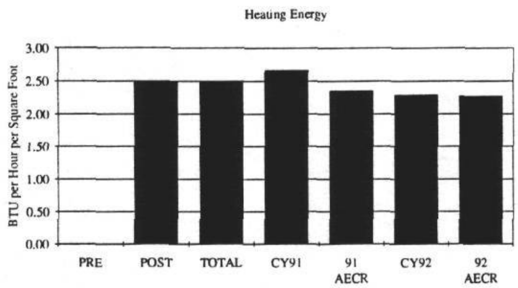


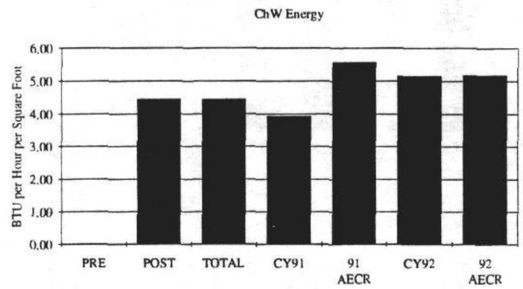


University Teaching Center
UTC - 101









University Teaching Center
University of Texas
Austin, Texas 78713

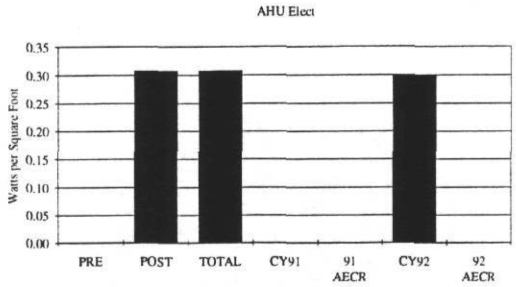
Size: 152,690 square feet
Construction: Hollow clay tile with a cut stone exterior, single pain clear operable are 9% of wall area, build-up roof on light weight insulation fill. Erected in 1984.
Lighting: High pressure sodium, fluorescent and incandescent.
Utilization: Classrooms.

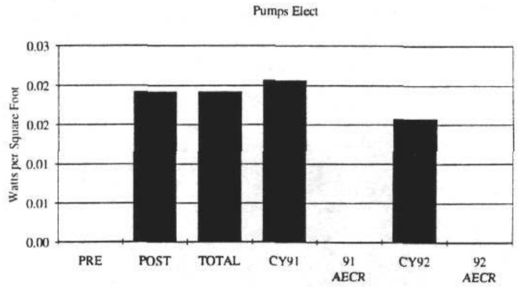
LoanSTAR Monitoring Start Date: October 13, 1990.
Retrofit Start Date: October 15, 1990.
Retrofit Completion Date: October 15, 1990.

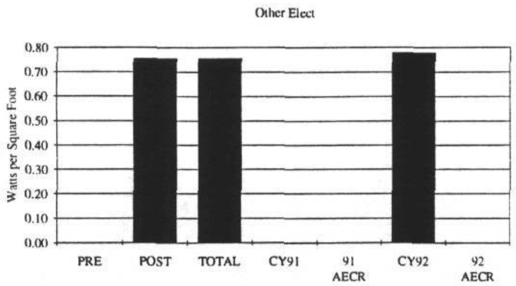
Retrofit Information:
- 3 position light switch,
- Variable air volume HVAC,
- Variable speed pumping.
- Retrofit Costs/Loan Amount: $366,255

Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

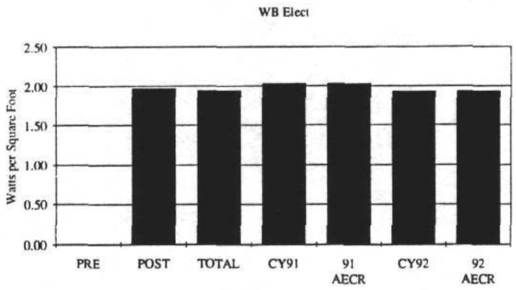
Miscellaneous plots for the University Teaching Center:

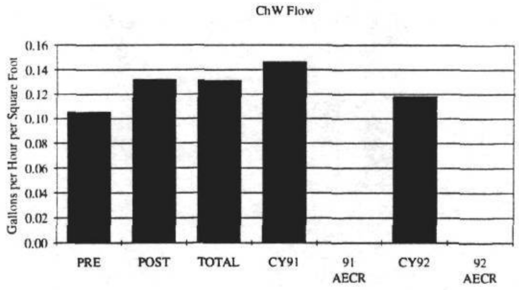


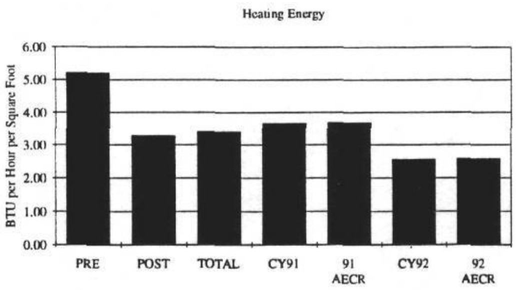


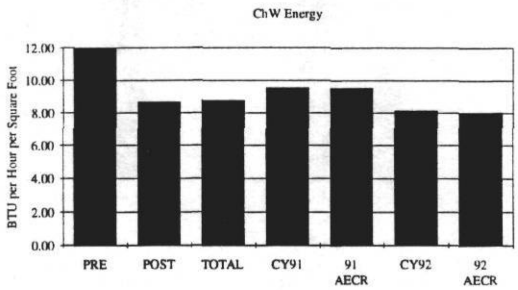


Perry Castaneda Library
PCL - 102









Perry Castaneda Library
University of Texas
Austin, Texas 78713

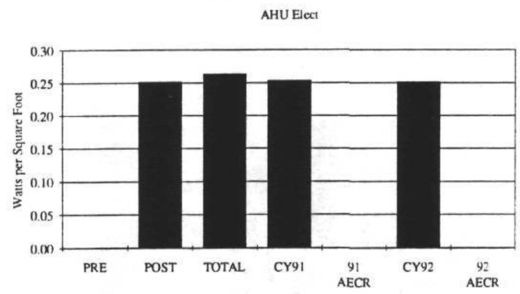
Size: 483,895 square feet
Construction: Limestone panels on concrete block, single pain tinted glass windows are 12% of total wall area, flat built-up roof on light weight insulation fill. Erected in 1977.
Lighting: Fluorescent.
Utilization: Book shelves, offices, open-stack library, and computer facilities.

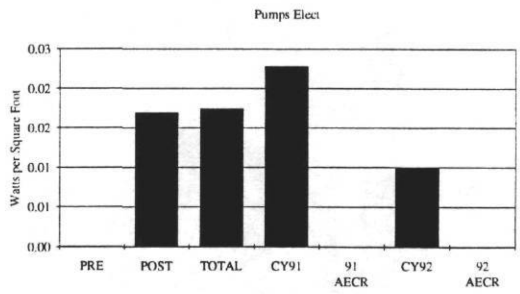
LoanSTAR Monitoring Start Date: October 8, 1990.
Retrofit Start Date: October 23, 1990.
Retrofit Completion Date: December 7, 1990.

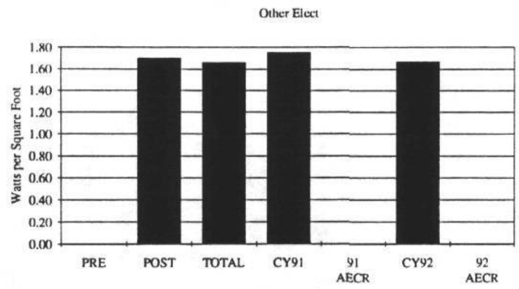
Retrofit Information:
- Occupancy sensors,
- Variable air volume HVAC,
- variable speed pumping.
- Retrofit Costs/Loan Amount: $735,143

Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

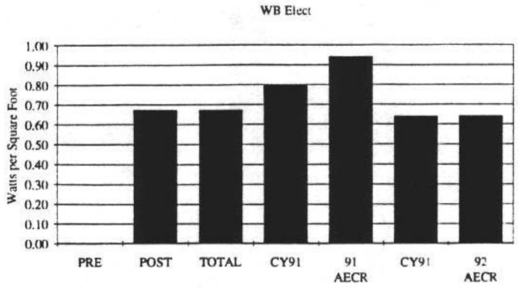
Miscellaneous plots for the Perry Castaneda Library:

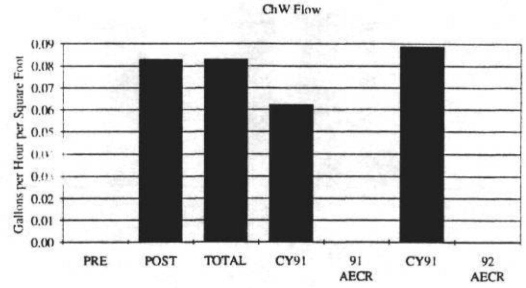


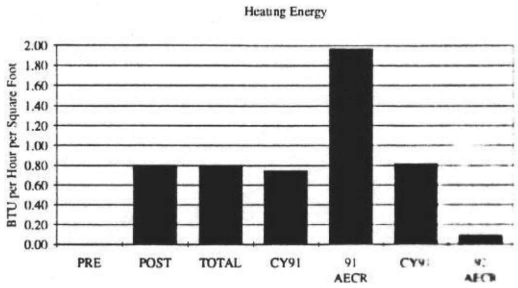


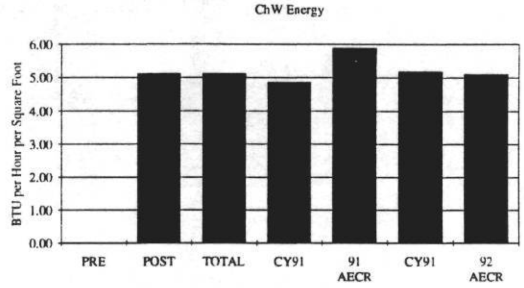


Garrison Hall
GAR 103/118









Garrison Hall
University of Texas
Austin, Texas 78713

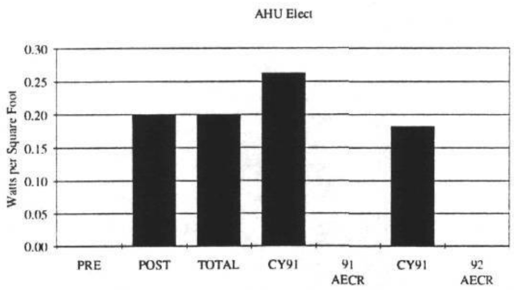
Size: 54,069 square feet
Construction: Hollow clay tile with a cut stone exterior, single pain clear operable windows are 19% of total wall, pitched roof with clay tile. Erected in 1926.
Lighting: Fluorescent with some incandescent.
Utilization: Classrooms, administrative offices and auditorium.

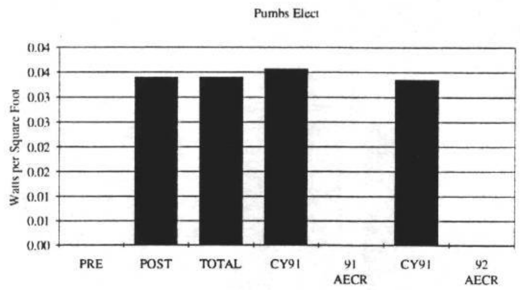
LoanSTAR Monitoring Start Date: October 13, 1990.
Retrofit Start Date: January 29, 1991.
Retrofit Completion Date: May 5, 1991.

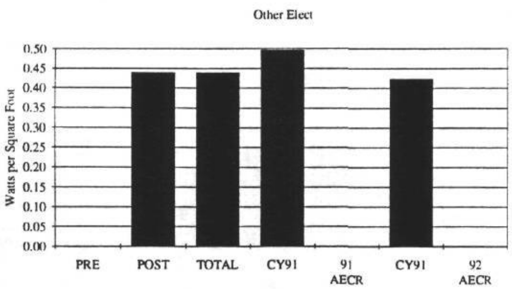
Retrofit Information:
- Variable air volume HVAC,
- Variable speed pumping.
- Retrofit Costs/Loan Amount: $87,486

Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

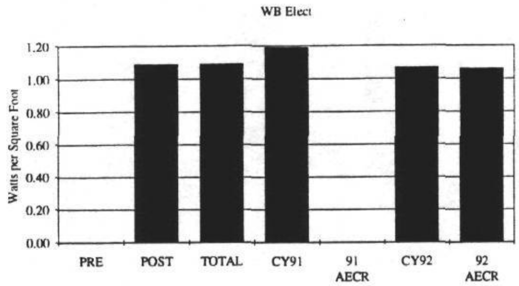
Miscellaneous plots for Garrison Hall:

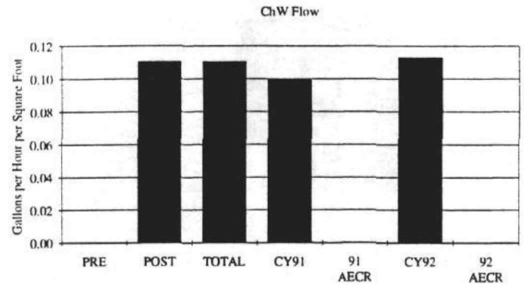


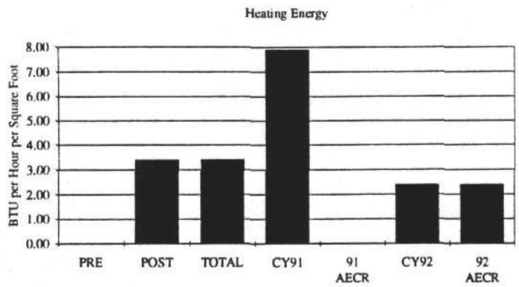


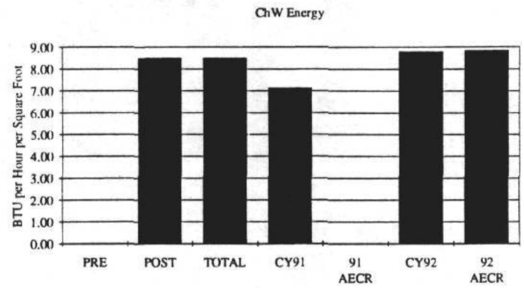


Gearing Hall
GEA - 104/119









Gearing Hall
University of Texas
Austin, Texas 78713

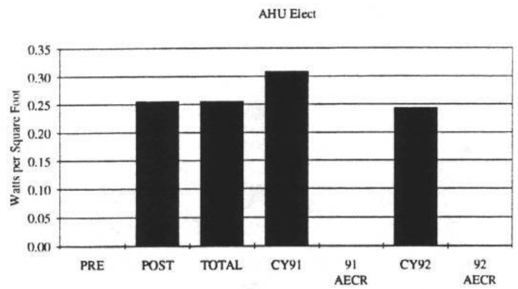
Size: 61,041 square feet
Construction: Hollow clay tile with a cut stone exterior, single pane clear operable windows are 18 % of total wall area, pitched roof with clay tiles. Erected in 1933
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices and labs.

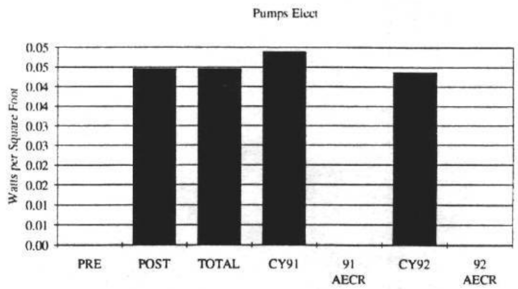
LoanSTAR Monitoring Start Date: October 13, 1990.
Retrofit Start Date: February 21, 1991.
Retrofit Completion Date: October 1, 1991

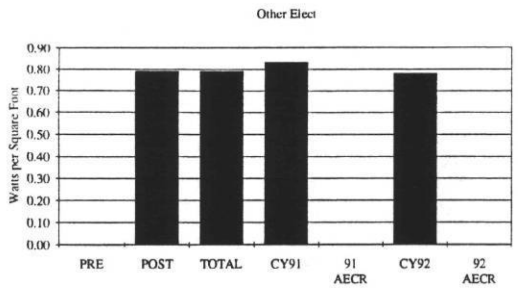
Retrofit Information:
- Variable air volume HVAC,
- variable speed pumping.
- Retrofit Costs/Loan Amount: $145,458

Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

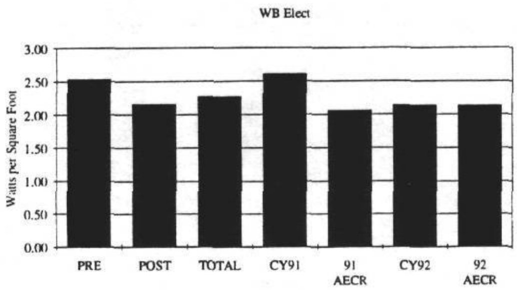
Miscellaneous plots for Gearing Hall:

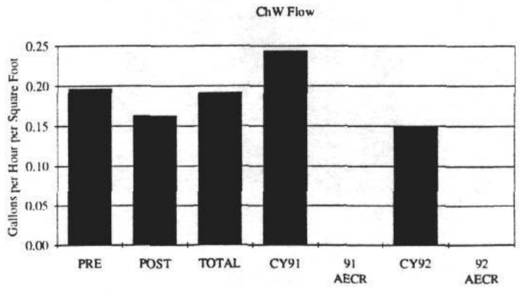


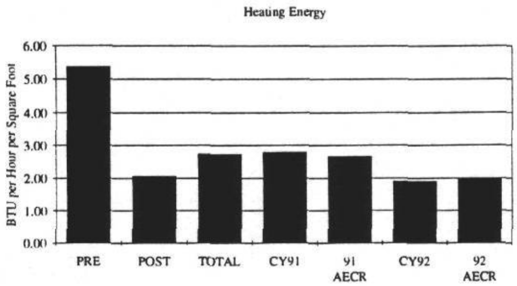


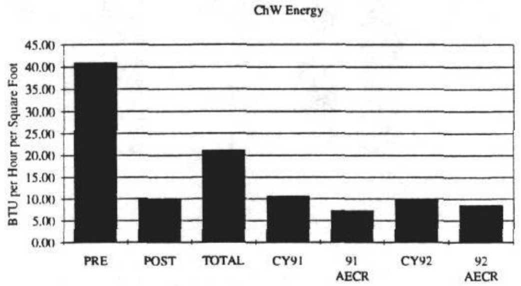


Waggener Hall
WAG - 105









Waggener Hall
University of Texas
Austin, Texas 78713

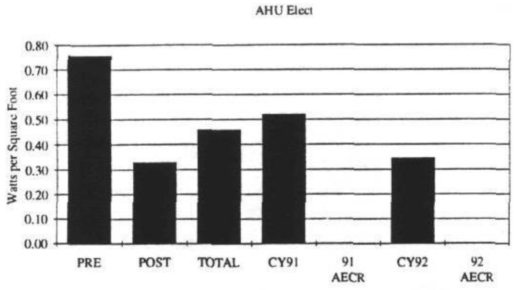
Size: 57,598 square feet
Construction: Hollow clay tile with a cut stone exterior, single pane clear operable windows are 22% of total wall, pitched roof with clay tiles. Erected in 1931.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices and labs.

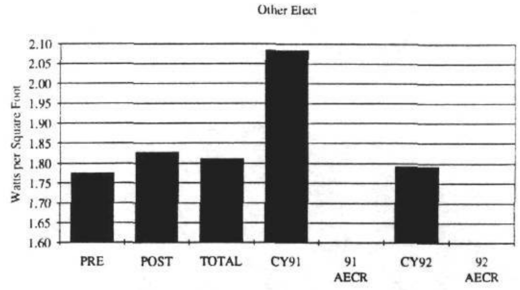
LoanSTAR Monitoring Start Date: October 13, 1990.
Retrofit Start Date: May 23, 1991.
Retrofit Completion Date: August 25, 1991

Retrofit Information:
- Variable air volume HVAC.
- Retrofit Costs/Loan Amount: $86,852

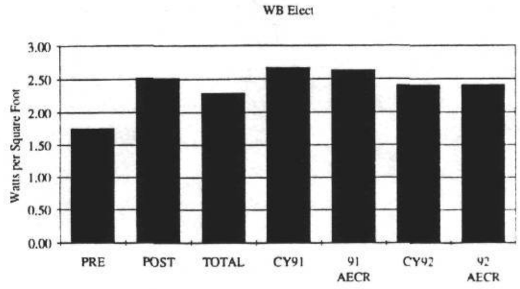
Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

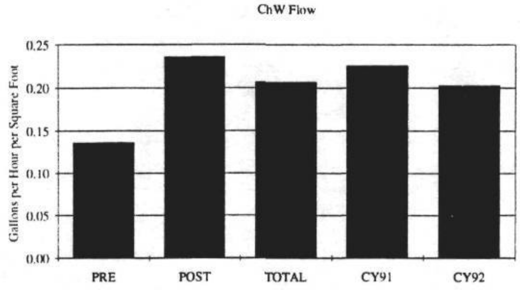
Miscellaneous plots for Waggener Hall:

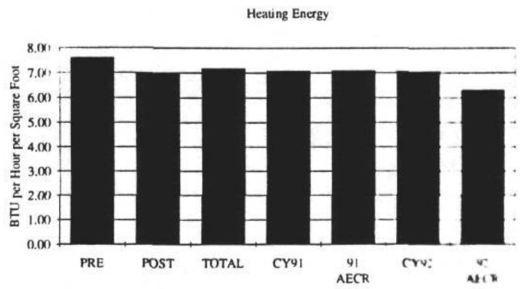


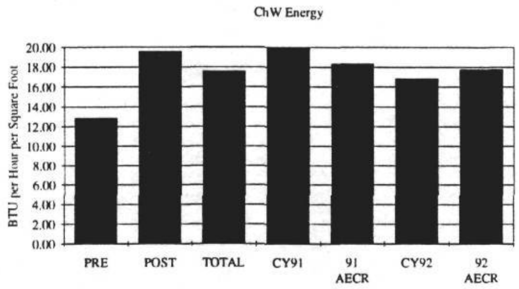


Welch Hall
WEL - 106









Welch Building
University of Texas
Austin, Texas 78713

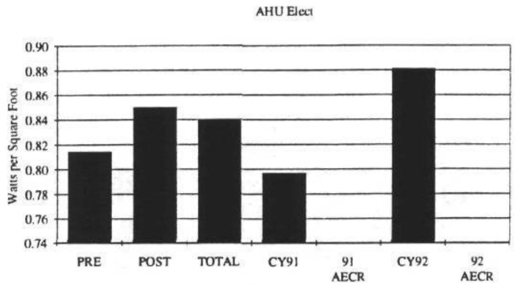
Size: 439,540 square feet
Construction: Red face brick on block, single pane tinted glass windows are 20% of total wall, build-up roof with 4.5" insulation. Erected in 1974.
Lighting: Fluorescent, incandescent, and mercury vapor.
Utilization: Classrooms, administrative offices and labs.

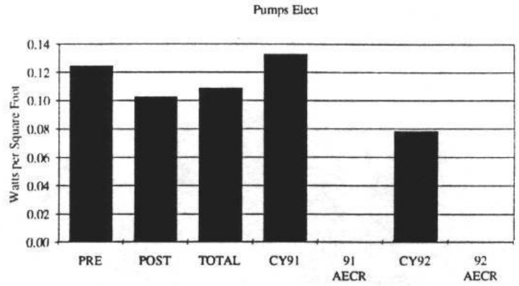
LoanSTAR Monitoring Start Date: October 13, 1990
Retrofit Start Date: June 1, 1991
Retrofit Completion Date: June 1, 1991

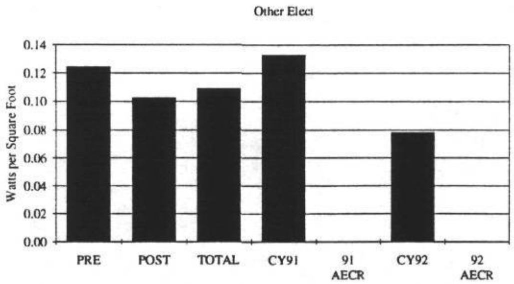
Retrofit Information:
- Replaced incandescent lighting,
- Variable air volume HVAC,
- Variable speed pumping.
- Retrofit Costs/Loan Amount: $781,443

Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

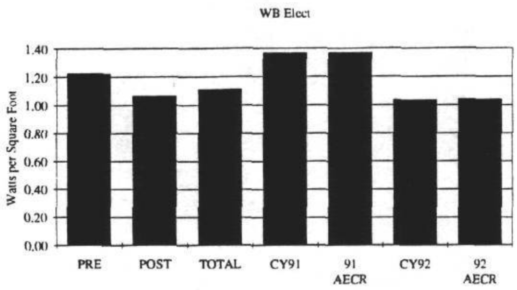
Miscellaneous plots for Welch Hall:

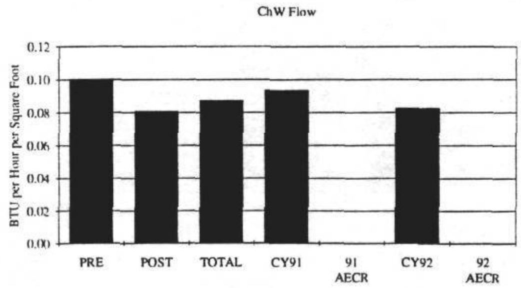


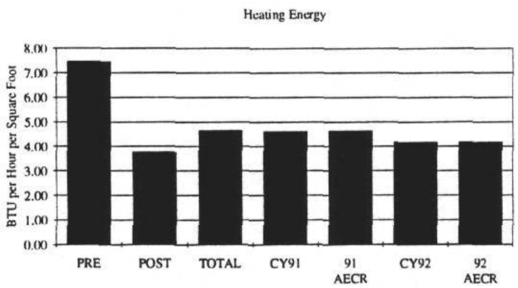


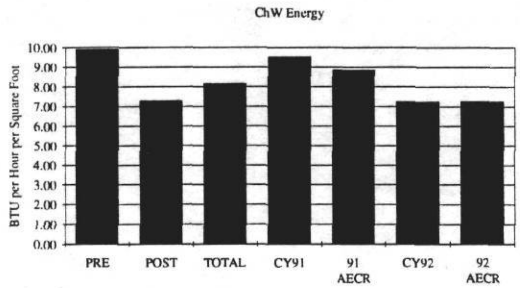


Burdine Hall
BUR - 107









Burdine Building
University of Texas
Austin, Texas 78713

Size: 103,441 square feet
Construction: Concrete with face brick, single pane windows, flat concrete roof.
Lighting: Fluorescent with some incandescent.
Utilization: Classrooms, administrative offices, lecture halls, and auditorium.

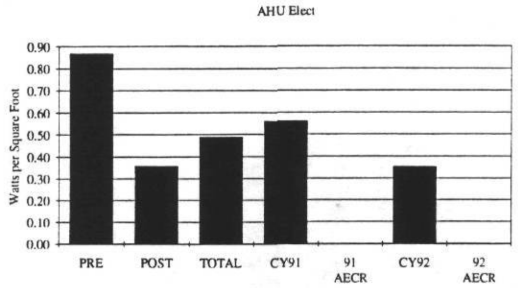
LoanSTAR Monitoring Start Date: October 13, 1990
Retrofit Start Date: May 15, 1991
Retrofit Completion Date: May 29, 1991

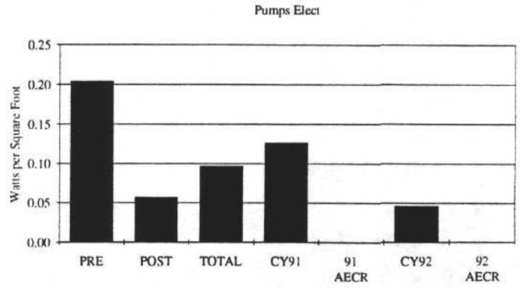
Retrofit Information:

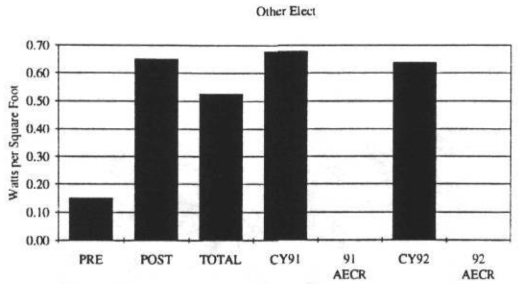
- Variable air volume HVAC,.
- Variable speed pumping,
- Retrofit Costs/Loan Amount: $134,959

Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

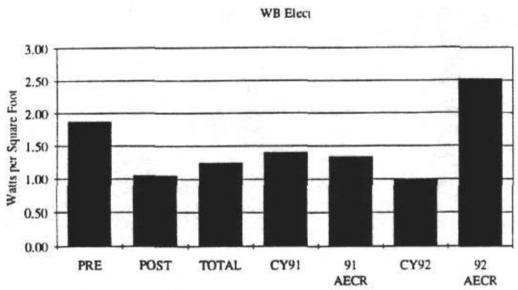
Miscellaneous plots for Burdine Hall:

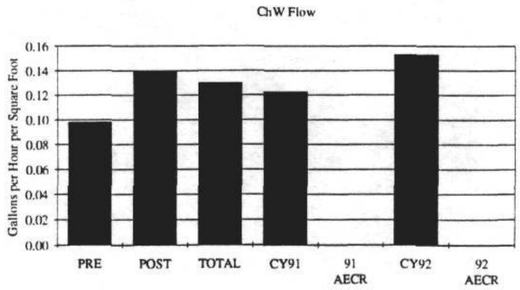


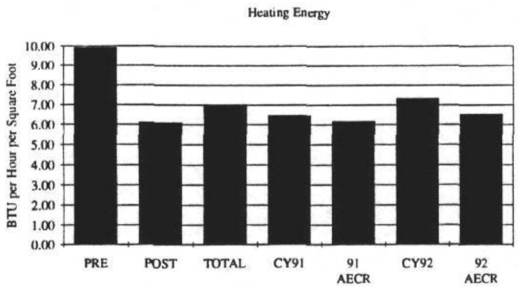


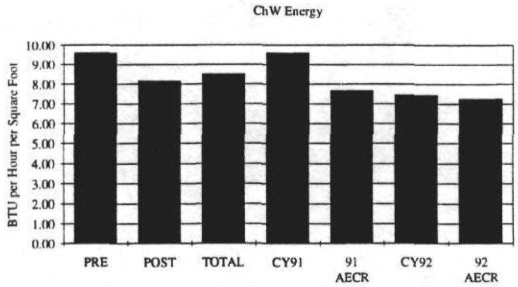


Nursing Building
NUR - 108









Nursing Building
University of Texas
Austin, Texas 78713

Size: 94,815 square feet
Construction: Pre-cast concrete panels, single pane clear glass windows, flat concrete roof.
Lighting: Fluorescent with some incandescent.
Utilization: Classrooms, lecture halls, and lounges.

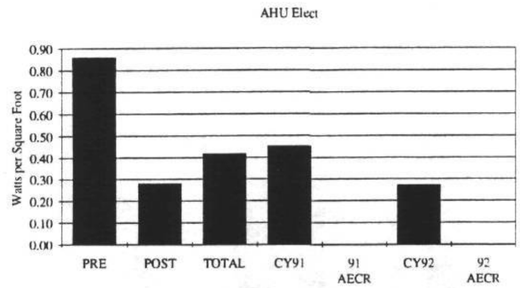
LoanSTAR Monitoring Start Date: October 13, 1990
Retrofit Start Date: April 15, 1991
Retrofit Completion Date: April 16, 1991

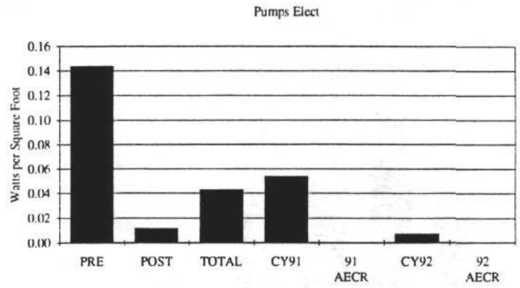
Retrofit Information:

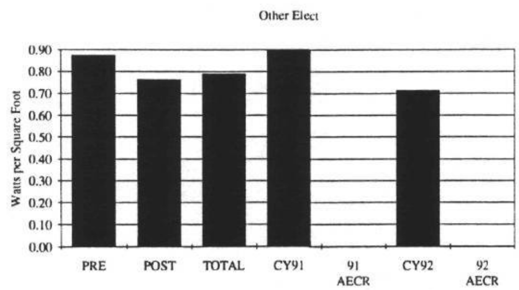
- Variable air volume HVAC,
- Variable speed pumping.
- Retrofit Costs/Loan Amount: $172,516

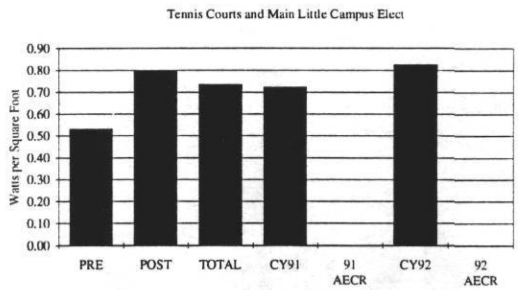
Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

Miscellaneous plots for the Nursing Building:

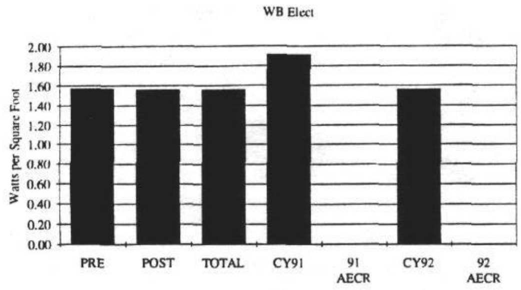


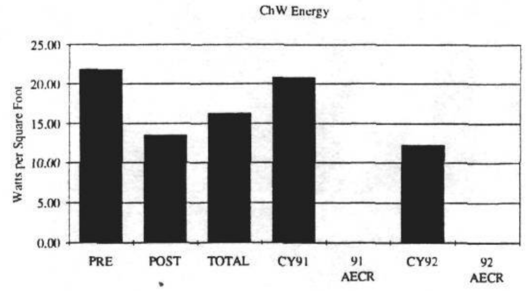


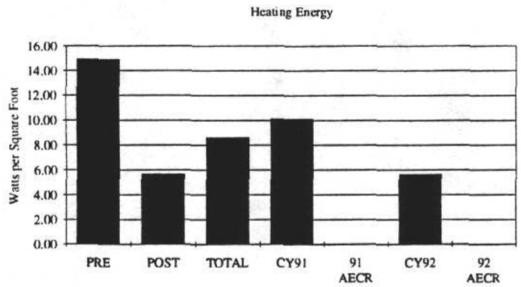




Winship Hall
WIN - 114







Winship Hall
University of Texas
Austin, Texas 78713

Size: 109,064 square feet
Construction: Cement block with face brick and plaster exterior, single pane clear operable windows are 10% of wall, built-up roof on lightweight concrete deck. Erected in 1961, addition in 1976.
Lighting: Fluorescent with some incandescent.
Utilization: Classrooms, administrative offices, and theater.

LoanSTAR Monitoring Start Date: October 11, 1990
Retrofit Start Date: July 2, 1991
Retrofit Completion Date: July 2, 1991

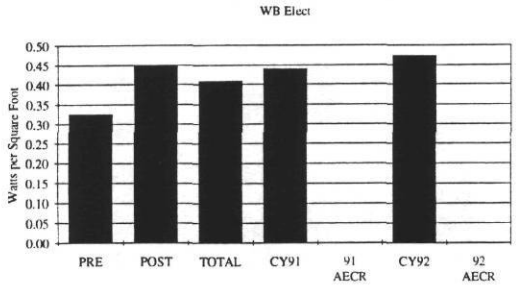
Retrofit Information:
- Variable air volume HVAC,
- Variable speed pumping.
- Retrofit Costs/Loan Amount: $211,812

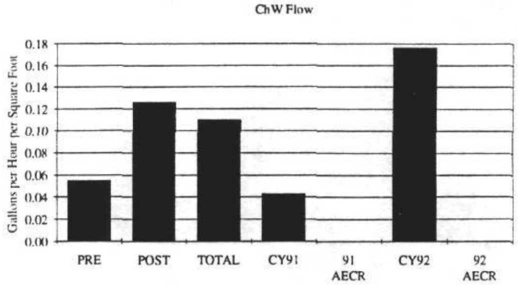
Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

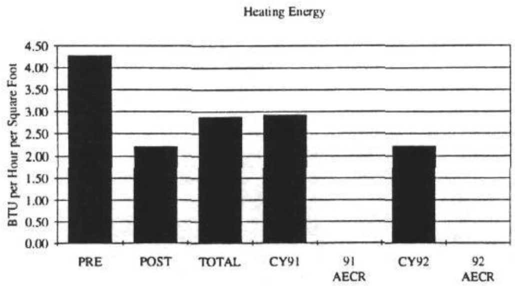
Miscellaneous plots:

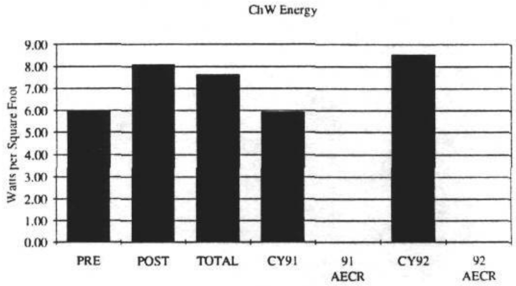
NONE.

Steindham Hall
STD - 115









R. A. Steindam Hall
University of Texas
Austin, Texas 78713

Size: 56,849 square feet
Construction: Concrete block with face brick, single pane clear operable windows are 28% of wall, 3" lightweight fill with 1" insulation roof. Erected in 1956.
Lighting: Fluorescent with some incandescent.
Utilization: Classrooms, administrative offices, and labs.

LoanSTAR Monitoring Start Date: October 11, 1990
Retrofit Start Date: April 31, 1991
Retrofit Completion Date: April 31, 1991

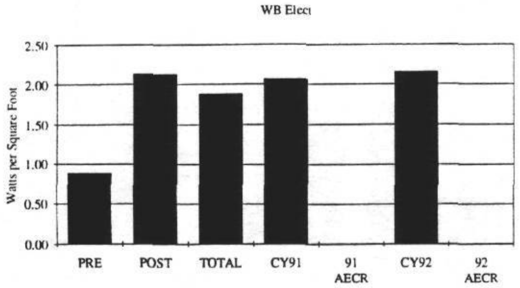
Retrofit Information:
- Hot and cold deck reset,
- Convert to VAV operation and re-sheave the AHU's supply and return fans,
- Install VFD's on the dual duct AHU's
- Retrofit Costs/Loan Amount: $19,369

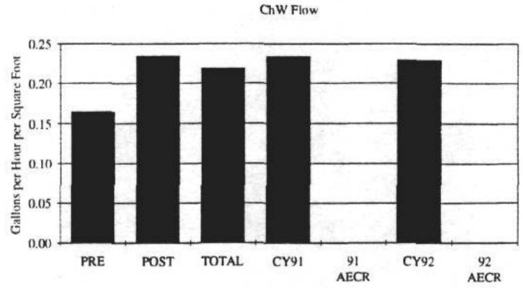
Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

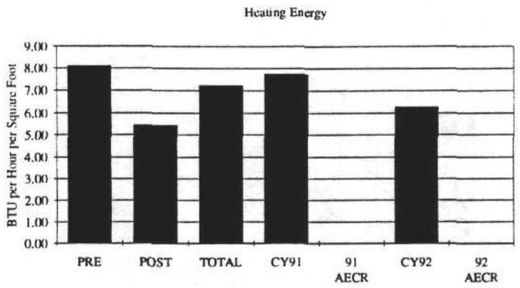
Miscellaneous plots:

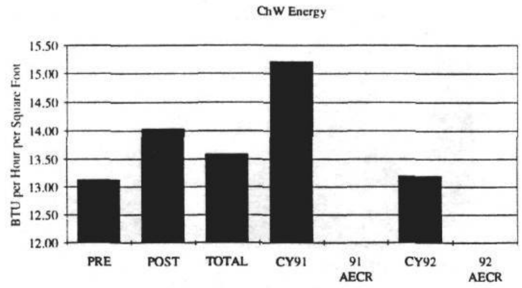
NONE.

Painter Hall
PAI - 116









Painter Building
University of Texas
Austin, Texas 78713

Size: 128,409 square feet
Construction: Hollow clay tile and brick, single pane clear operable windows are 24% of wall, clay tile roof.
Lighting: Fluorescent with some incandescent.
Utilization: Classrooms, administrative offices, and labs.

LoanSTAR Monitoring Start Date: October 10, 1990
Retrofit Start Date: June 1, 1991
Retrofit Completion Date: March 1, 1992

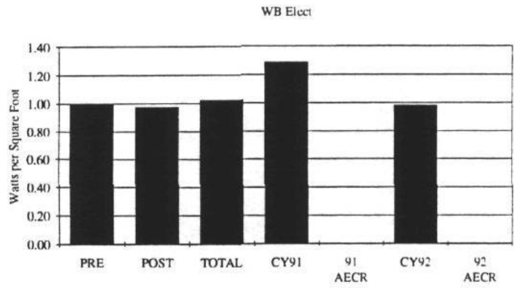
Retrofit Information:
- Variable air volume HVAC,
- Variable speed chilled water pumping.
- Retrofit Costs/Loan Amount: $254,311

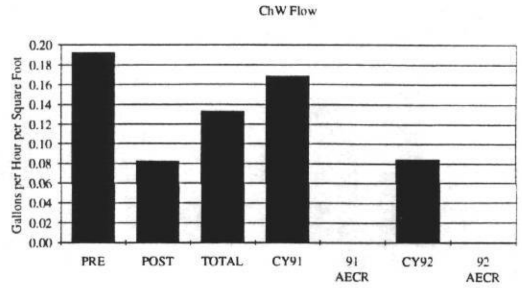
Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

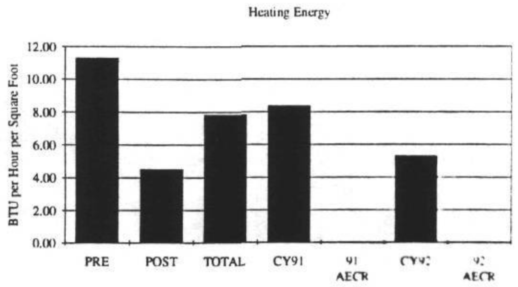
Miscellaneous plots:

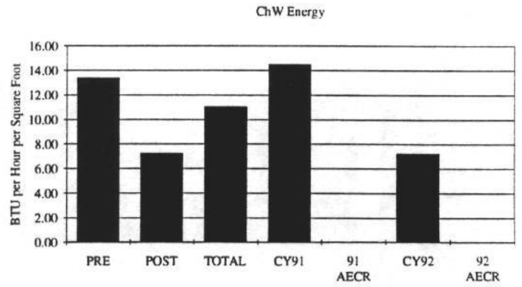
NONE.

W. C. Hogg Hall
WCH - 117









W. C. Hogg Building
University of Texas
Austin, Texas 78713

Size: 48,905 square feet
Construction:
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, workshops, and auditorium..

LoanSTAR Monitoring Start Date: October 10, 1990
Retrofit Start Date: February 1, 1991
Retrofit Completion Date: July 1, 1991

Retrofit Information:

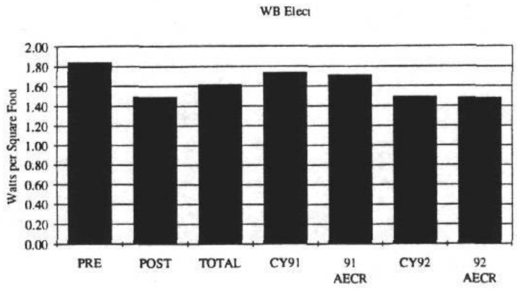
- Variable air volume HVAC,
- Variable speed pumping
- Replace economizer.
- Retrofit Costs/Loan Amount: $77,165

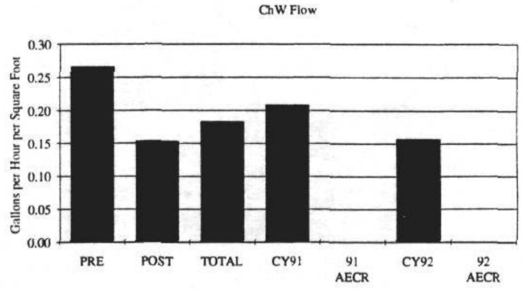
Utilities Unit Costs: $0.0455/kWh, $7.425/MMBtu (CW), and $6.20/MMBtu (Steam). Heating is provided by Steam.

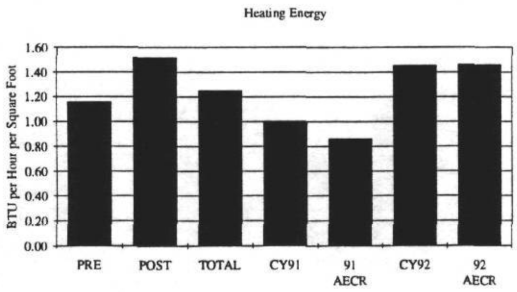
Miscellaneous plots:

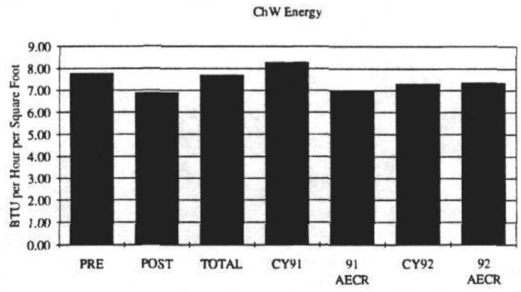
NONE.

University Hall
UNV - 111









University Hall
University of Texas at Arlington
Arlington, Texas 76019

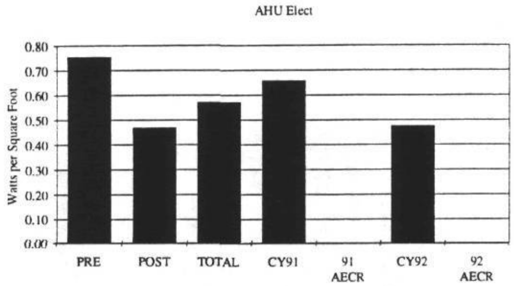
Size: 123,450 square feet
Construction: Face brick, single pane, tinted, operable windows are 10% of wall. Erected in 1970.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, and lecture halls.

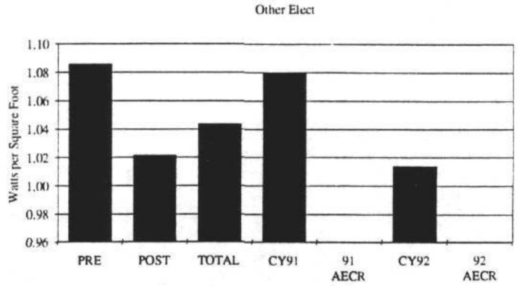
LoanSTAR Monitoring Start Date: December 11, 1990.
Retrofit Start Date: July 1, 1991.
Retrofit Completion Date: October 1, 1991.

Retrofit Information:
- Variable speed pumping for chilled water pumps,
- Lighting controls,
- VAV conversion of AHU's
- Retrofit Costs/Loan Amount: $273,012

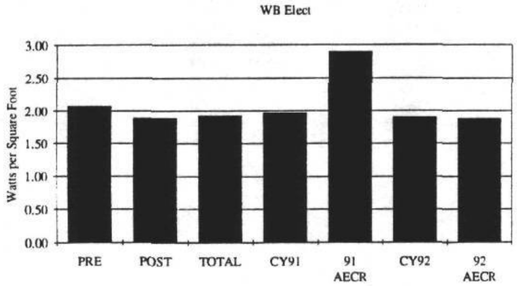
Utilities Unit Costs: $0.02931/kWh, $5.827/MMBtu (CW), and $3.44/MMBtu (Steam). Heating is provided by Steam.

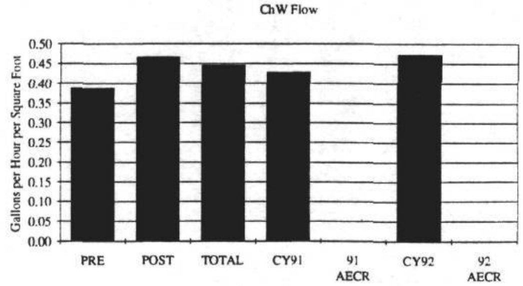
Miscellaneous plots for University Hall:

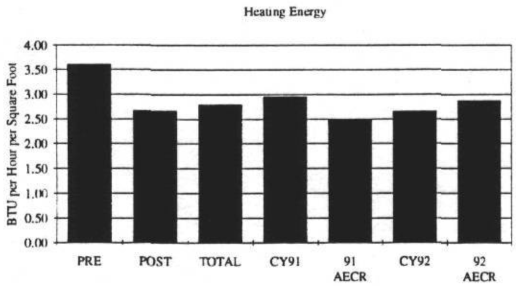


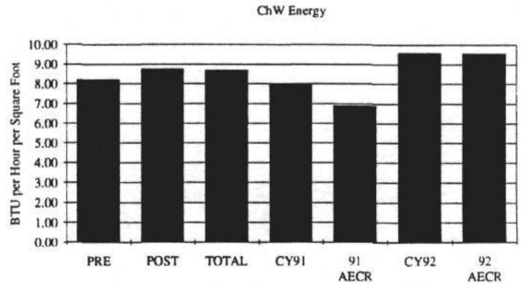


Business Building
BUS - 112









Business Building
University of Texas at Arlington
Arlington, Texas 76019

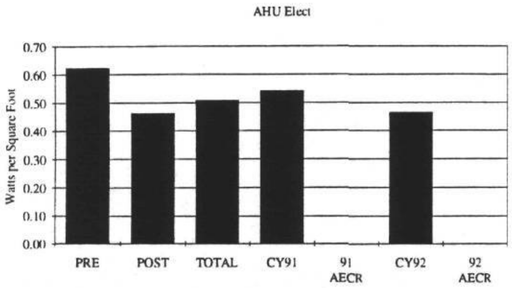
Size: 149,900 square feet
Construction: Face brick, single pane brown tinted are 4% of wall area. Erected in 1976.
Lighting: Fluorescent.
Utilization: Classrooms and lecture halls.

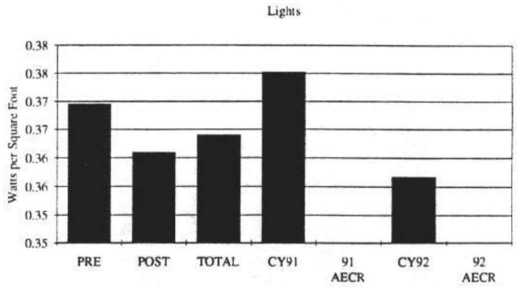
LoanSTAR Monitoring Start Date: December 22, 1990.
Retrofit Start Date: July 12, 1991.
Retrofit Completion Date: August 1, 1991.

Retrofit Information:
- Lighting controls.
- VAV conversion of AHU's.
- Retrofit Costs/Loan Amount: $329,629

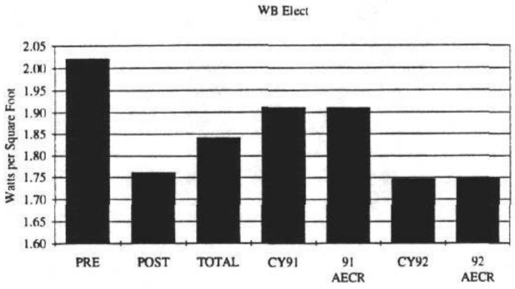
Utilities Unit Costs: $0.02931/kWh, $5.827/MMBtu (CW), and $3.44/MMBtu (Steam). Heating is provided by Steam.

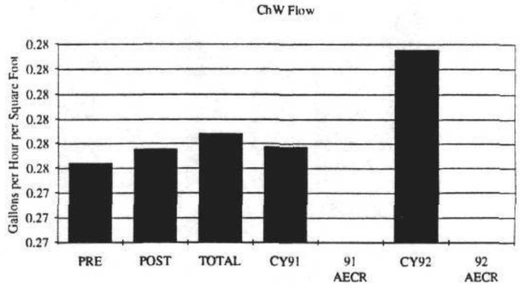
Miscellaneous plots for the Business Building:

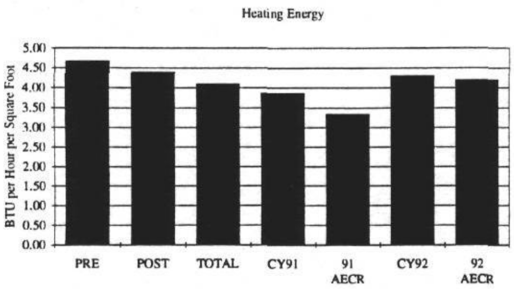


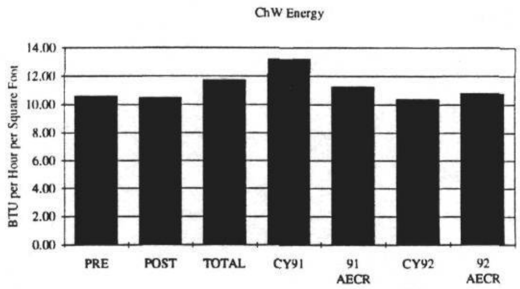


Fine Arts Building
FNA - 113









Fine Arts Building
University of Texas at Arlington
Arlington, Texas 76019

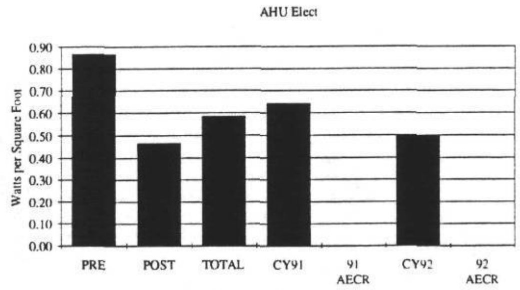
Size: 223,000 square feet
Construction: Face Brick, single pane brown tinted windows are 6% of wall. Erected in 1972.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, and lecture halls.

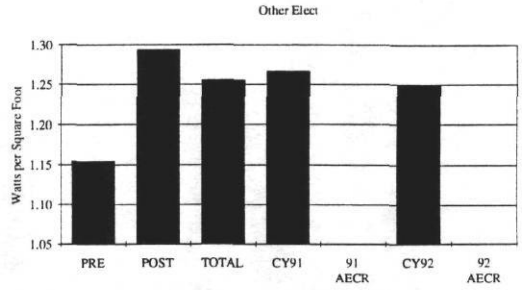
LoanSTAR Monitoring Start Date: December 11, 1990.
Retrofit Start Date: May 14, 1991.
Retrofit Completion Date: August 22, 1991.

Retrofit Information:
- Variable speed pumping for chilled water pumps,
- Lighting controls,
- VAV conversion of AHU's.
- Retrofit Costs/Loan Amount: $310,739

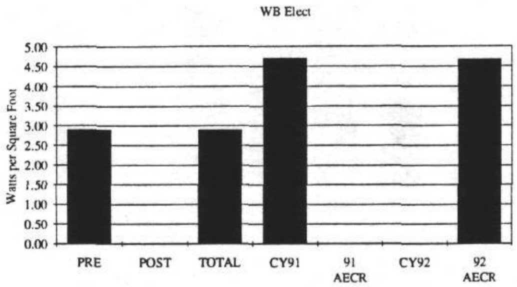
Utilities Unit Costs: $0.02931/kWh, $5.827/MMBtu (CW), and $3.44/MMBtu (Steam). Heating is provided by Steam.

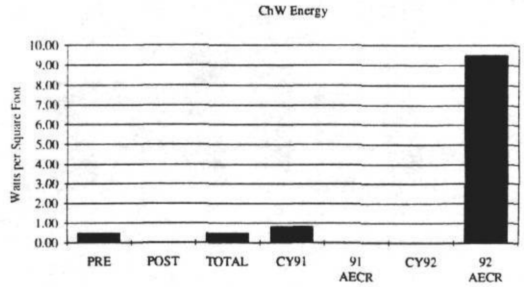
Miscellaneous plots for the Fine Arts Building:

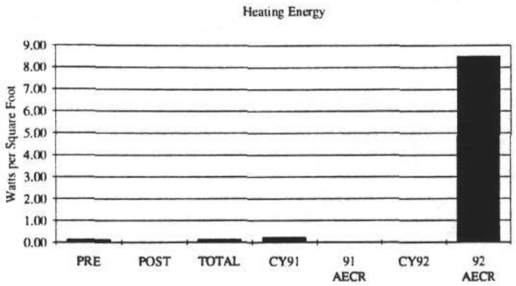




Stephen F. Austin Building
SFA - 202







Stephen F. Austin Building
Texas Capital Complex
Austin, Texas 78711

Size: 470,000 square feet
Construction: 3"-4" thick red granite with windows totaling 25% of wall area. Erected in 1973.
Lighting: Fluorescent.
Utilization: Administrative offices

LoanSTAR Monitoring Start Date: March 12, 1990.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

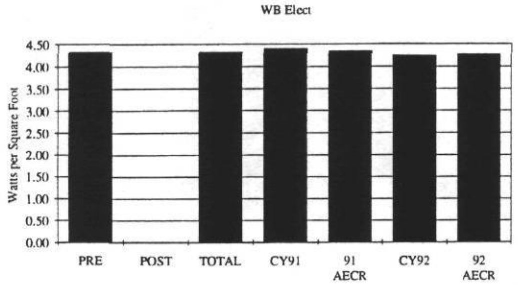
Retrofit Information:
- Variable speed motor drives and speed controllers,
- Variable speed controls for chilled water pumps.
- Retrofit Costs/Loan Amount: $654,542

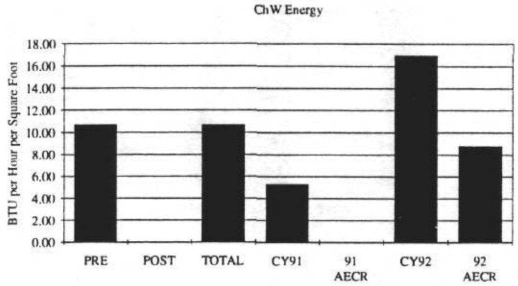
Utilities Unit Costs: $0.02651/kWh, $3.2/MMBtu (CW), and $3.84/MMBtu (Steam). Heating is provided by Steam.

Miscellaneous plots:

Miscellaneous plots of MCC, AHU, lighting, pumps, and chiller electric are not available.

John H. Reagan Building
JHR - 203





John H. Reagan Building
Texas Capital Complex
Austin, Texas, 78711

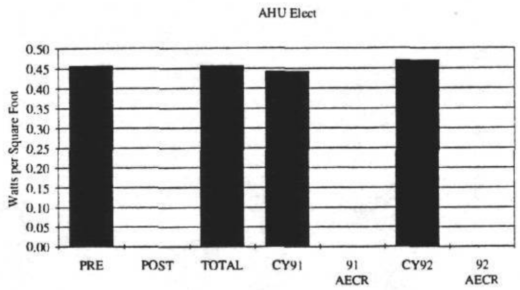
Size: 169,756 square feet
Construction: Texas granite exterior, single glazed windows on all sides, flat roof. Erected in 1961.
Lighting: Fluorescent.
Utilization: Administrative offices.

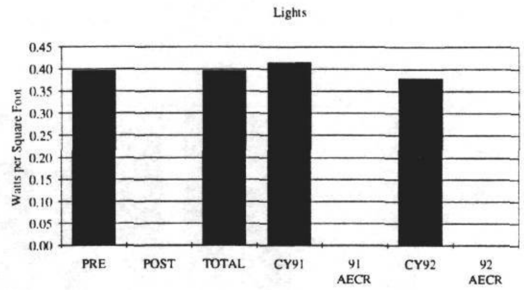
LoanSTAR Monitoring Start Date: January 1, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

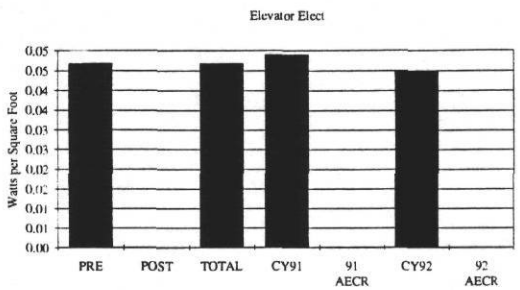
Retrofit Information:
- Reduced lighting levels,
- Night set back on AHU's,
- Motion detectors.
- Retrofit Costs/Loan Amount: $68,541

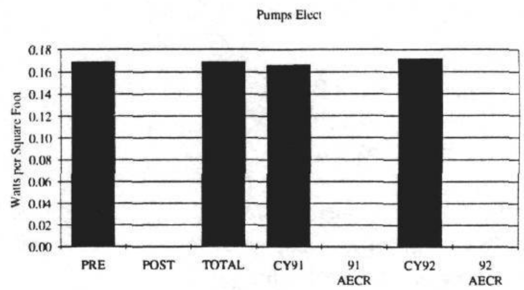
Utilities Unit Costs: $0.0347/kWh, $3.25/MMBtu (CW). Heating is provided from central plant which is not metered.

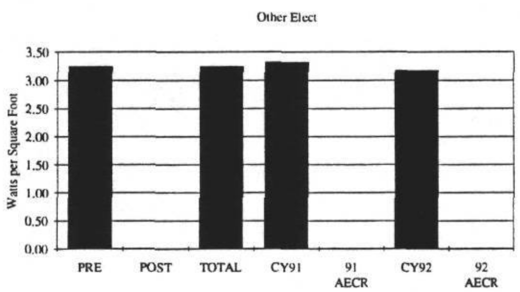
Miscellaneous plots for the John H. Reagan Building:



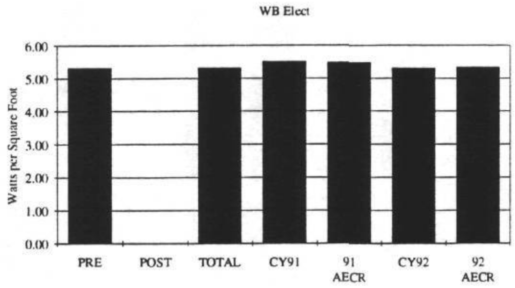








James E. Rudder Building
JER - 205



James E. Rudder Building
Texas Capitol Complex
Austin, Texas 78711

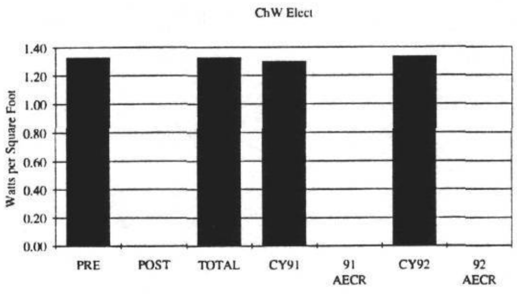
Size: 80,000 square feet
Construction: Masonry with a cast stone on north face and a brick-veneer facing on remaining faces, single glazed windows with interior blinds. Renovated in 1988.
Lighting: Fluorescent.
Utilization: Administrative offices, data processing, and computer facility.

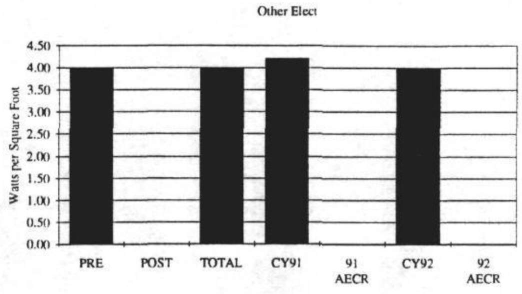
LoanSTAR Monitoring Start Date: December 11, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Domestic HW pump shut down,
- Two speed fans on cooling towers,
- Economizer cycles,
- Night set back for AHU's,
- Motion (occupancy) detectors for the restrooms,
- Retrofit Costs/Loan Amount: $13,235

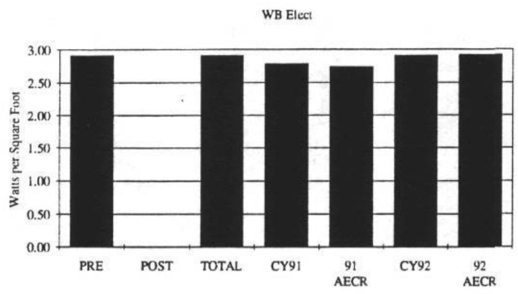
Utilities Unit Costs: $0.0347/kWh. Chilled water and heating are not measured from the central plant.

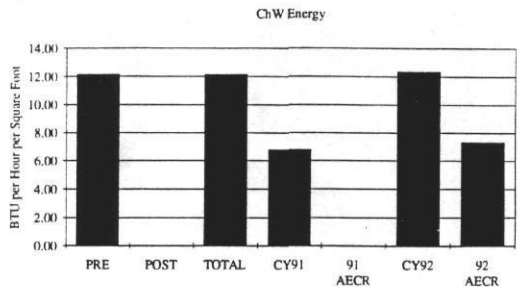
Miscellaneous plots for the James E. Rudder Building:





Insurance Building
INS - 206





State Insurance Annex Building
Texas Capital Complex
Austin, Texas 78711

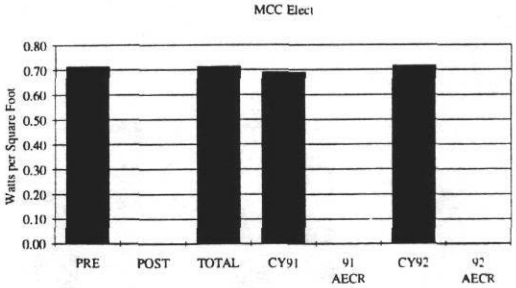
Size: 102,000 square feet
Construction: Texas granite exterior, single pane with aluminum solar screen windows, flat roof. Erected in 1961.
Lighting: Fluorescent.
Utilization: Administrative offices.

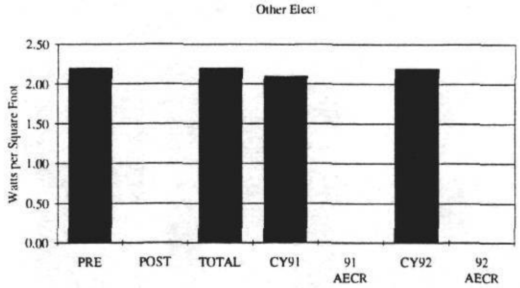
LoanSTAR Monitoring Start Date: December 11, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Domestic HW pump shut down,
- Night set back for AHU's,
- Motion (occupancy) detectors for the restrooms,
- Reduce outside air intake.
- Retrofit Costs/Loan Amount: $24,836

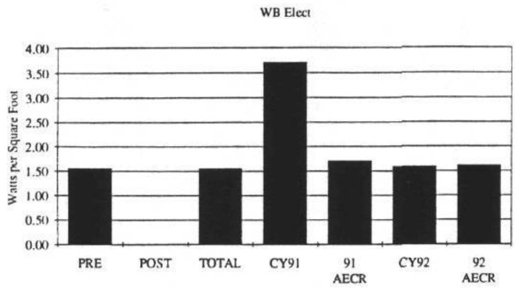
Utilities Unit Costs: $0.0348/kWh. Chilled water and heating is not measured from the central plant.

Miscellaneous plots for the Insurance Building:





Insurance Annex Building
INX - 207



State Insurance Annex Building
Texas Capital Complex
Austin, Texas 78711

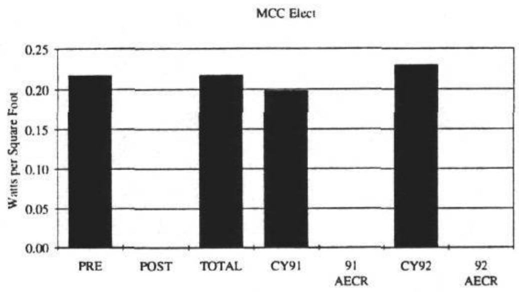
Size: 62,000 square feet
Construction: Concrete and brick, solar screen, tint and solar shade for north and south windows, east and west windows are unprotected, flat roof. Erected in 1958.
Lighting: Fluorescent.
Utilization: Administrative offices.

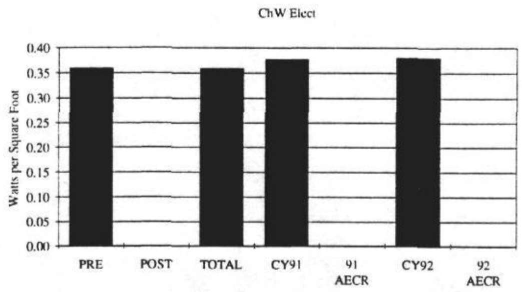
LoanSTAR Monitoring Start Date: December 11, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

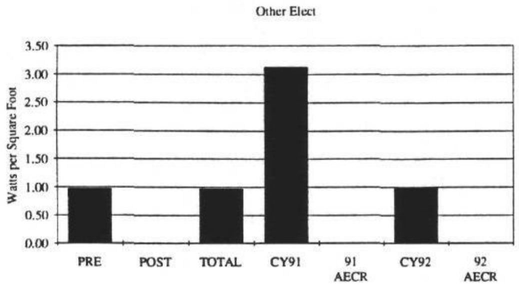
Retrofit Information:
- Domestic HW pump shut down,
- Night set back for AHU's,
- Motion (occupancy) detectors for the restrooms,
- Retrofit Costs/Loan Amount: $69,412

Utilities Unit Costs: $0.0349/kWh. Chilled water and heating is not measured from the central plant.

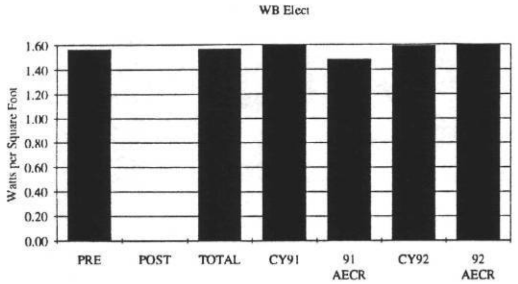
Miscellaneous plots for the Insurance Annex Building:

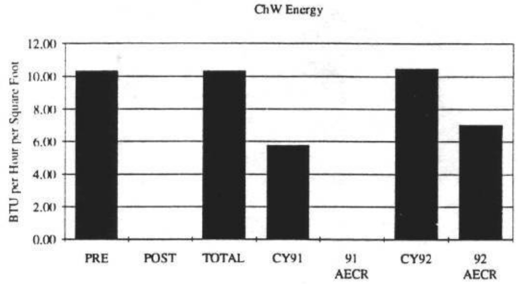






Archive Building
ARC - 208





Lorenzo De Zavala Archives & Library Building
Texas Capital Complex
Austin, Texas 78711

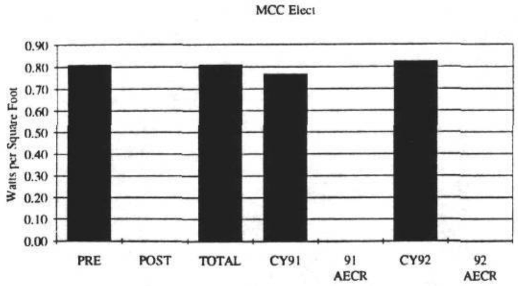
Size: 120,000 square feet
Construction: Texas granite exterior, single pane clear operable windows are 6% of wall area, flat roof. Erected 1960.
Lighting: Fluorescent.
Utilization: Texas State Library and Archives and some administrative offices.

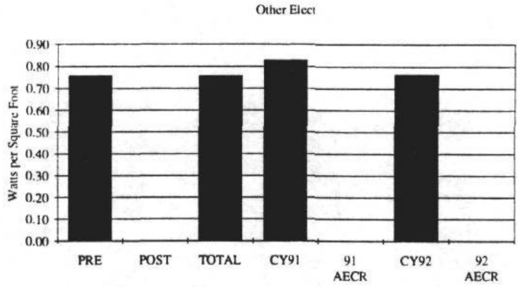
LoanSTAR Monitoring Start Date: December 11, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Domestic HW pump shut down,
- Install variable frequency drives,
- Motion (occupancy) detectors for the restrooms,
- VAV retrofits,
- Night set back for AHU's,
- Reduced lighting levels.
- Retrofit Costs/Loan Amount: $38,421

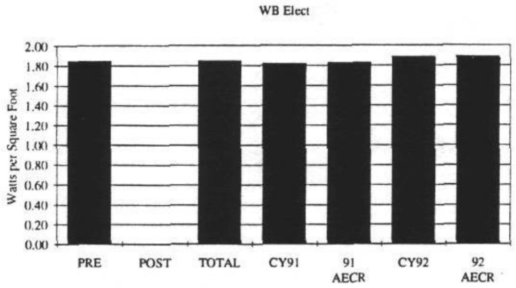
Utilities Unit Costs: $0.0254/kWh. Heating is not measured from the central plant.

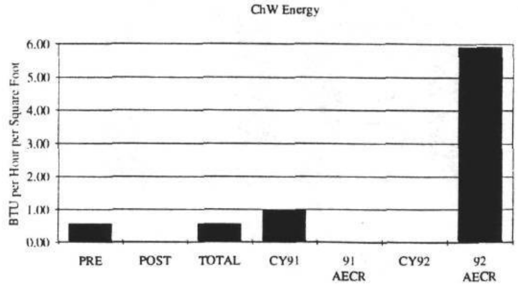
Miscellaneous plots for the Archive Building:





William B. Travis Building
WBT - 209





William B. Travis Building
Texas Capital Complex
Austin, Texas 78711

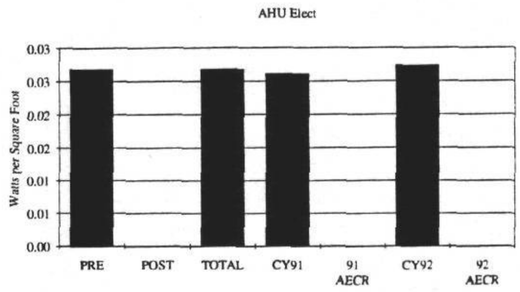
Size: 491,000 square feet
Construction: 3"-4" red granite slab and 1" expanded polystyrene insulation, double pane windows, flat roof with 2" rigid board insulation. Erected in 1985
Lighting: Fluorescent.
Utilization: Administrative offices.

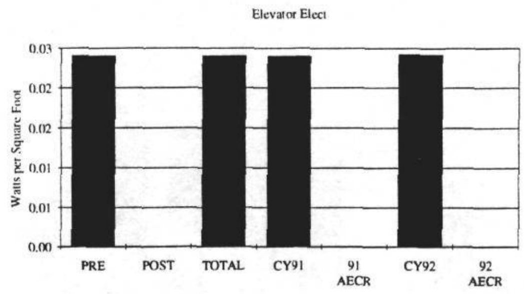
LoanSTAR Monitoring Start Date: December 20, 1990.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

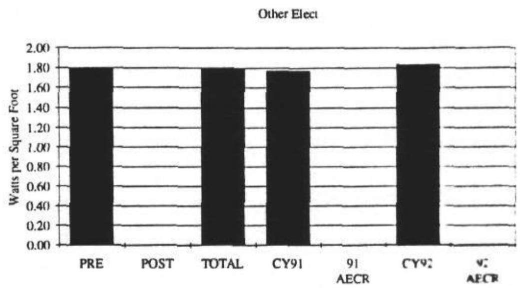
Retrofit Information:
- Lighting controls,
- Retrofit Costs/Loan Amount: $133,900

Utilities Unit Costs: $0.03483/kWh. Heating is not measured from the central plant.

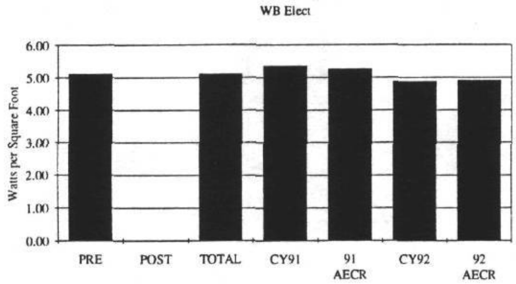
Miscellaneous plots for the William B. Travis Building:

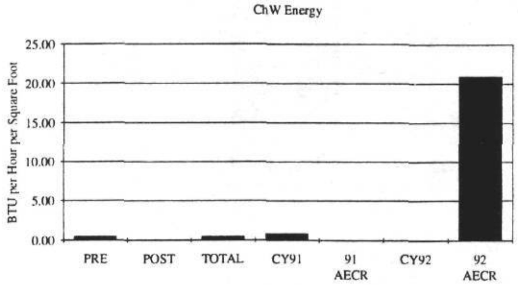






Lyndon B. Johnson Building
LBJ - 210





Lyndon B. Johnson
Texas Capital Complex
Austin, Texas 78711

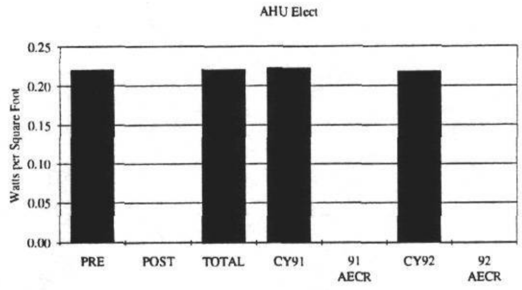
Size: 308,080 square feet
Construction: 3"-4" red granite slab, single pane windows, flat roof with vermiculite all-weather Crete. Erected in 1969.
Lighting: Fluorescent with some incandescent.
Utilization: Administrative offices.

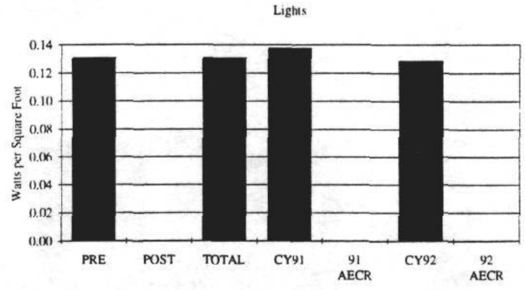
LoanSTAR Monitoring Start Date: December 11, 1990.
Retrofit Start Date: N/A
Retrofit Completion Date: N/A.

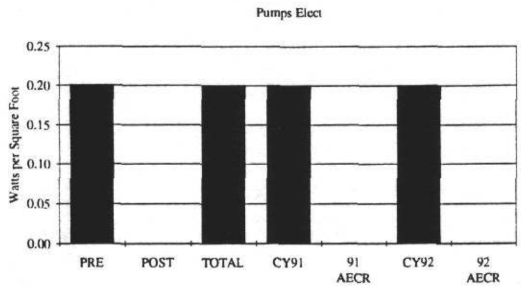
Retrofit Information:
- Reduce HW pump speed,
- Motion detectors and lighting controls,
- Variable speed motors
- Replacement of incandescent lighting.
- Retrofit Costs/Loan Amount: $383,600

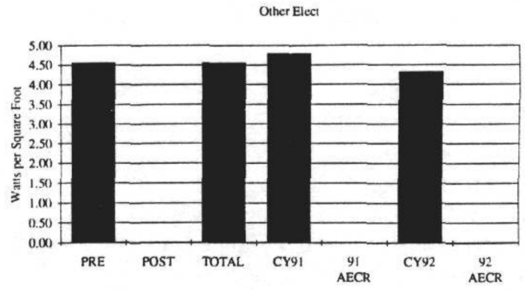
Utilities Unit Costs: $0.0347/kWh. Heating is not measured from the central plant.

Miscellaneous plots for the Lyndon B. Johnson Building:

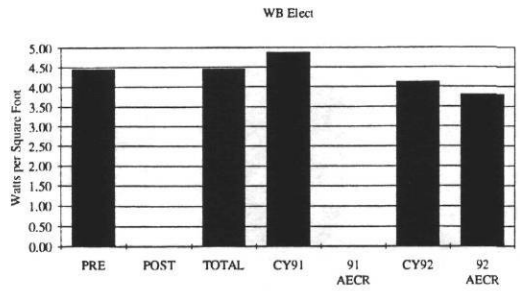


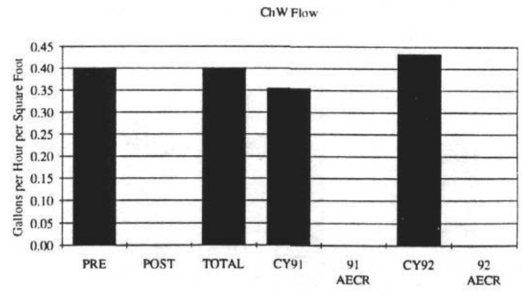


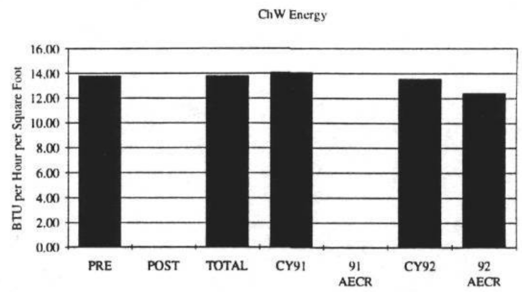




J. H. Winter's Complex
JHW - 211







John H Winters Complex
Texas Capital Complex
Austin, Texas 78711

Size: 503,000 square feet
Construction: Three separate building served by a common central chilling plant, standard brick walls, single pane tinted windows. Erected in 1984.
Lighting: Fluorescent with incandescent in the ground floor lobby area..
Utilization: Administrative offices.

LoanSTAR Monitoring Start Date: March 12, 1990.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

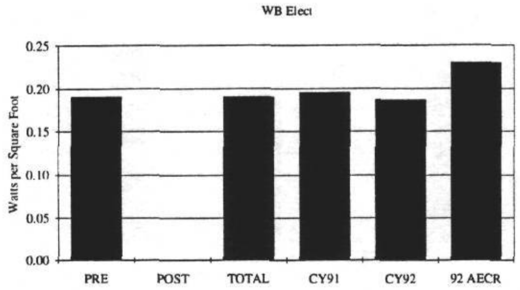
Retrofit Information:
- Upgrade energy management system,
- Lighting modifications.
- Retrofit Costs/Loan Amount: $273,612

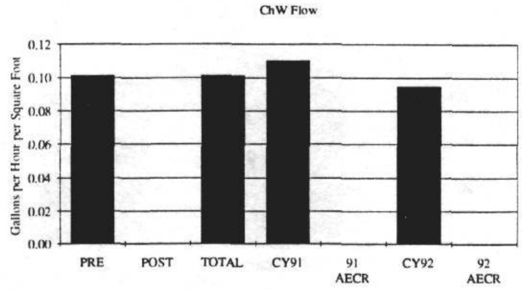
Utilities Unit Costs: $0.0347/kWh

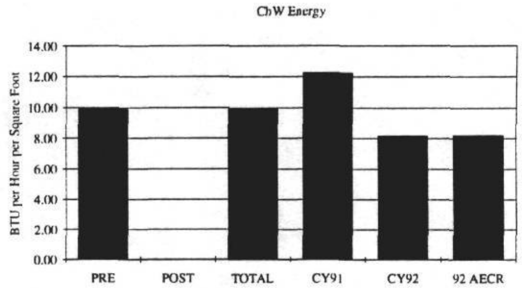
Miscellaneous plots:

NONE.

UTHSC San Antonio Medical School
SAM - 142







Medical School
University of Texas Health Science Center San Antonio
San Antonio, Texas 78284

Size: 606,097 square feet
Construction: Red face brick on block, single pane tinted windows are 20% of wall area, flat built-up roof. Erected in 1976.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, lecture halls, and medical labs.

LoanSTAR Monitoring Start Date: March 19, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

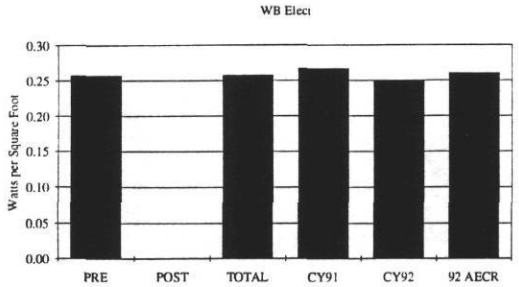
Retrofit Information:
- Variable volume air handler conversion,
- Variable speed pumping,
- Solar screens,
- Retrofit Costs/Loan Amount: $117,684

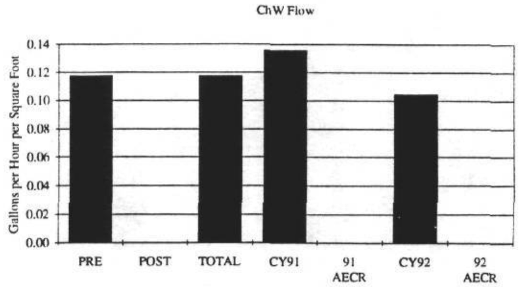
Utilities Unit Costs: $0.0258/kWh, $8.775/MMBtu (CW), and $/MMBtu (Steam). Heating is not measured.

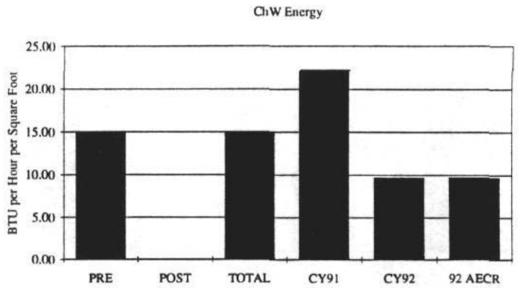
Miscellaneous plots:

NONE.

UTHSC San Antonio Dental School
SAD - 141







Dental School
University of Texas Health Sciences Center San Antonio
San Antonio, Texas 78284

Size: 484,019 square feet
Construction: Face brick on block, single pane tinted windows, built up roof with 15" of rigid insulation on a concrete deck. Erected in 1975.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, teaching labs, research labs, dental rooms, animal rooms and computer rooms.

LoanSTAR Monitoring Start Date: March 19, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

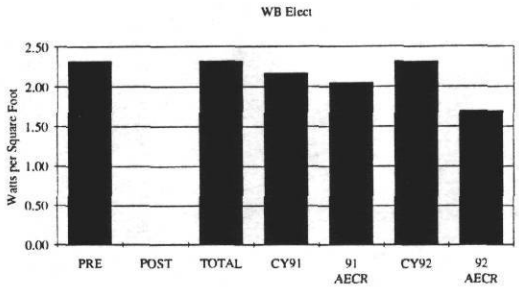
Retrofit Information:
- Isolation zones/ hot deck dampers
- Variable speed pumping for chilled water pumps,
- Solar screens,
- VAV conversion of AHU's.
- Retrofit Costs/Loan Amount: $99,120

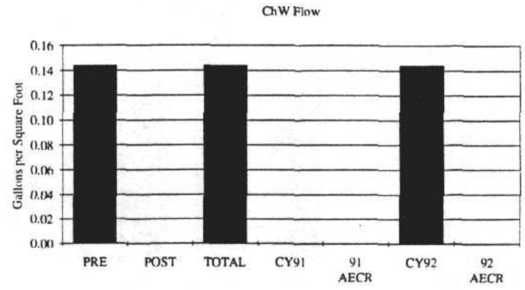
Utilities Unit Costs: $0.0258/kWh, $8.775/MMBtu (CW). Heating is not measured.

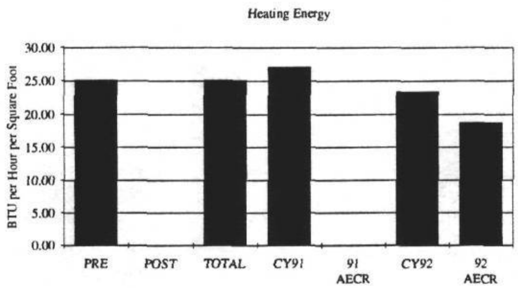
Miscellaneous plots:

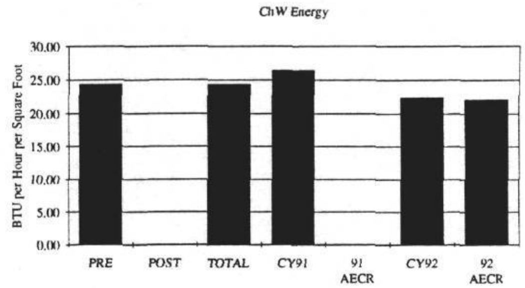
NONE.

School of Public Health
SPH - 300









School of Public Health
University of Texas Health Sciences Center Houston
Houston, Texas 77225

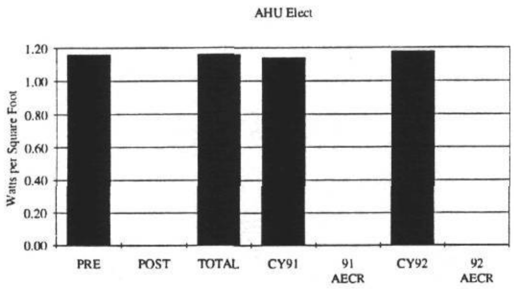
Size: 233,738 square feet
Construction: 8" standard brick, single pane with built in vertical blinds, vertical cement fins for solar shading, flat insulated roof. Erected in 1975, addition in 1985.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, laboratory research, and library.

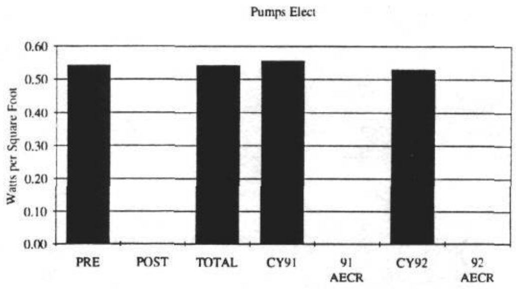
LoanSTAR Monitoring Start Date: December 30, 1990.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

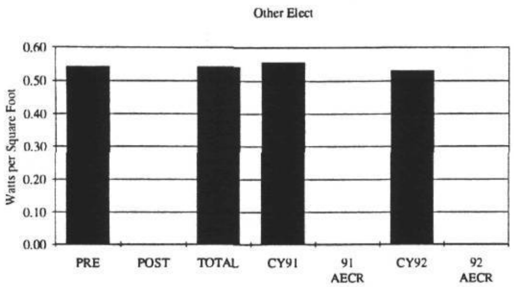
Retrofit Information:
- Install EMCS system,
- VAV conversion of AHU's
- Retrofit Costs/Loan Amount: $1,589,672

Utilities Unit Costs: $0.02659/kWh, $4.33/MMBtu (CW), and $5.21/MMBtu (Steam). Heating is provided by Steam.

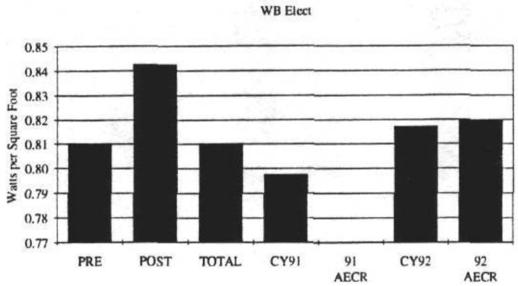
Miscellaneous plots for the School of Public Health:

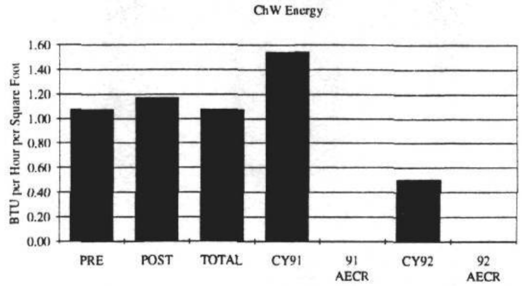


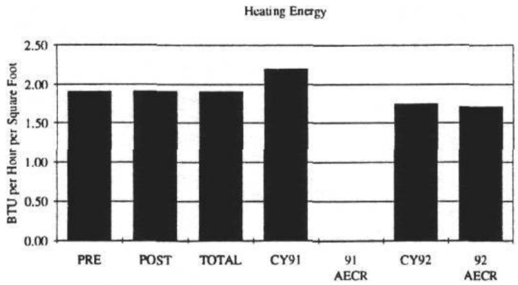




Stroman High School
SHS - 126







Stroman High School
Victoria Independent School District
Victoria, Texas 77901

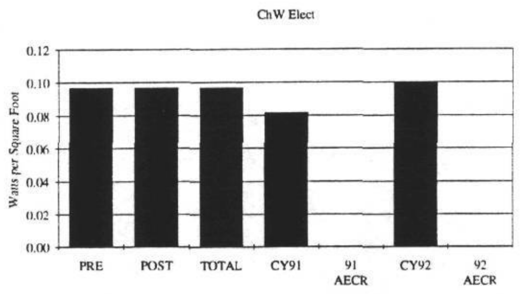
Size: 210,500 square feet
Construction: 6 individual units of differing construction.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, and gym.

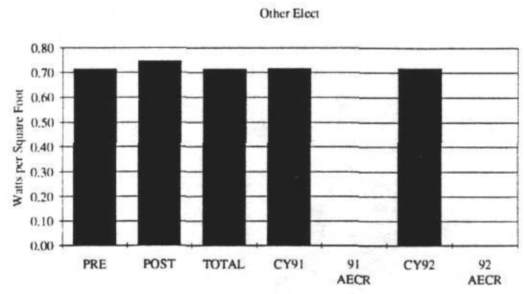
LoanSTAR Monitoring Start Date: June 4, 1991.
Retrofit Start Date: August 15, 1991.
Retrofit Completion Date: August 15, 1991.

Retrofit Information:
- Energy management system,
- Replacement of absorption chiller.
- Retrofit Costs/Loan Amount: $193,606

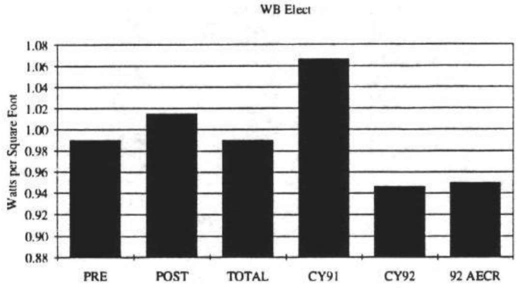
Utilities Unit Costs: $0.0/3359/kWh and $4.11/MMBtu (NG). Heating is provided by natural gas.

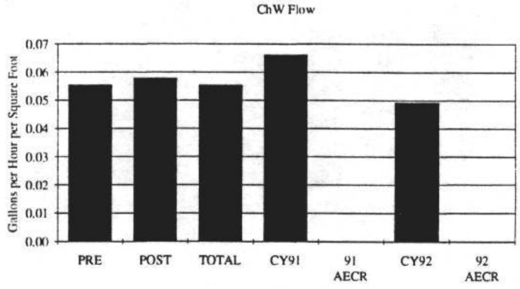
Miscellaneous plots for Stroman High School:

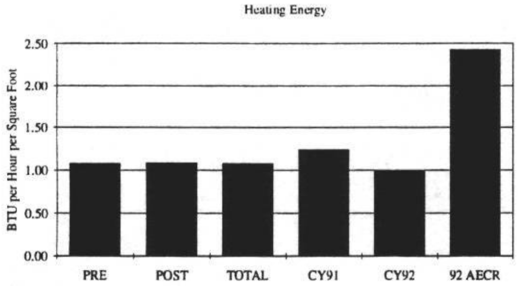


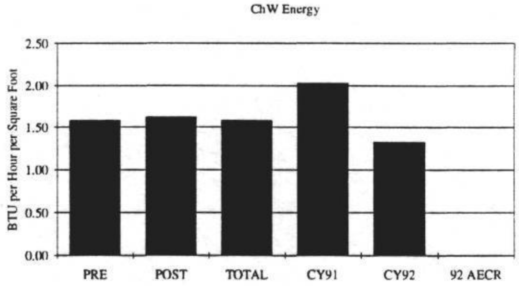


Victoria High School
VHS - 127









Victoria High School
Victoria Independent School District
Victoria, Texas 77901

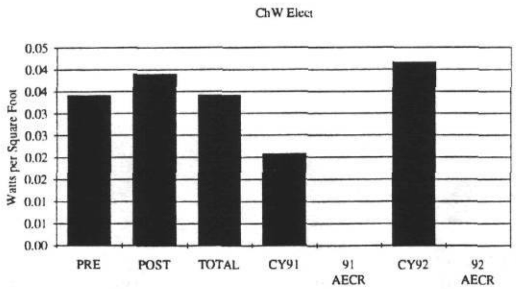
Size: 257,000 square feet
Construction: Brick slab, flat roof.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, and field house.

LoanSTAR Monitoring Start Date: June 4, 1991.
Retrofit Start Date: August 15, 1991.
Retrofit Completion Date: August 15, 1991.

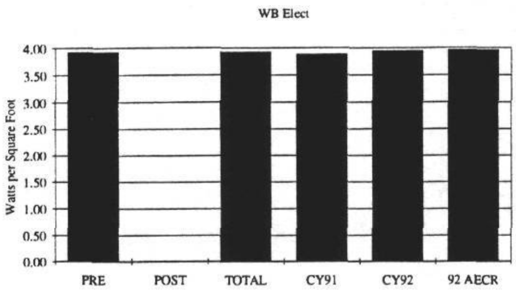
Retrofit Information:
- Energy management system,
- Replacement of absorption chiller.
- Retrofit Costs/Loan Amount: $149,100

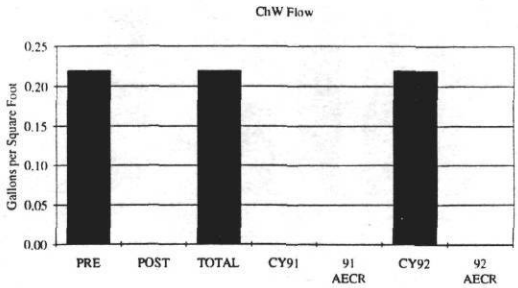
Utilities Unit Costs: $0.03064/kWh and $4.07/MMBtu (NG). Heating is provided by natural gas.

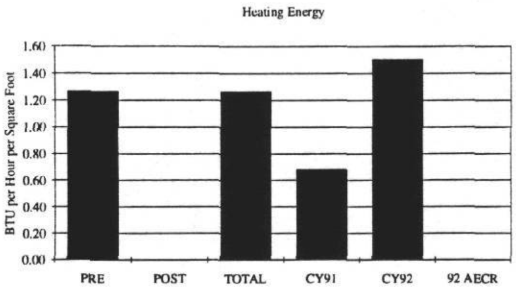
Miscellaneous plots for Victoria High School:

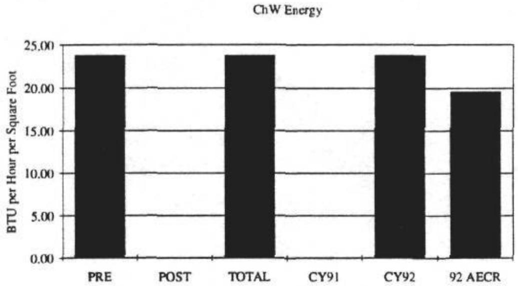


Clinical Sciences Building
CSB - 401









Clinical Sciences Building
University of Texas Medical Branch - Galveston
Galveston, Texas 77550

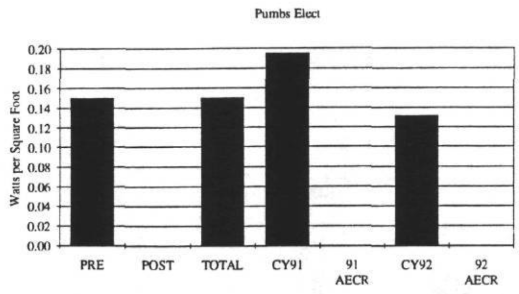
Size: 124,870 square feet
Construction: Erected in 1970.
Lighting: Mixture of incandescent and fluorescent.
Utilization: Classrooms, administrative offices, laboratory and morgue facility.

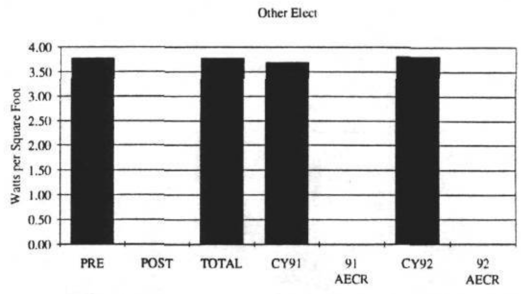
LoanSTAR Monitoring Start Date: June 18, 1991
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Hot water pump speed control,
- Chilled water pump speed control,
- Lighting modifications,
- Retrofit Costs/Loan Amount: $36,894

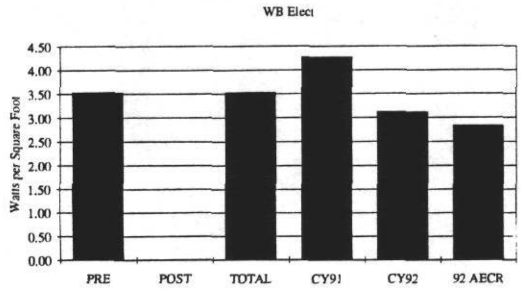
Utilities Unit Costs: $0.02659/kWh, $7.52/MMBtu (CW). Heating is not metered.

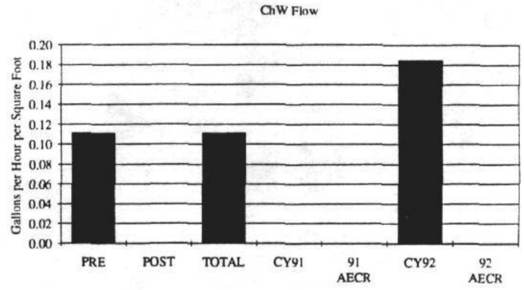
Miscellaneous plots for the Clinical Sciences Building

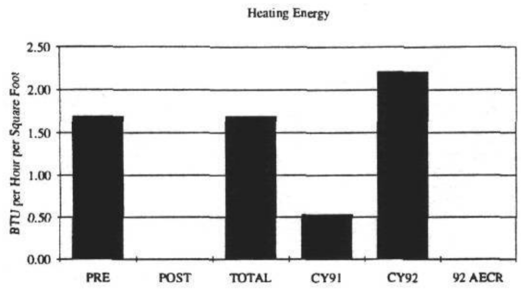


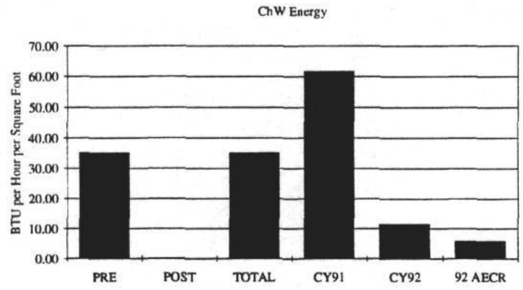


Basic Sciences Building
BSB - 402









Basic Sciences Building
University of Texas Medical Branch - Galveston
Galveston, Texas 77550

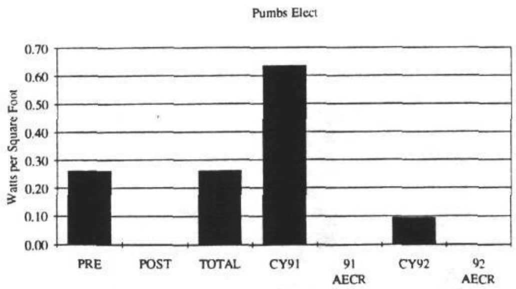
Size: 137,856 square feet
Construction: Brick facade/ exposed concrete column construction. Erected in 1971.
Lighting: Mixture of fluorescent and incandescent.
Utilization: Classrooms, administrative offices, and conference rooms.

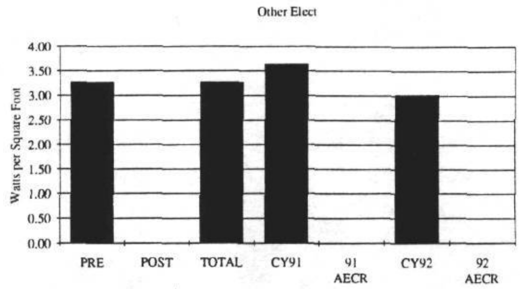
LoanSTAR Monitoring Start Date: June 19, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Solar screening,
- New controls for chilled water pumps,
- Lighting modifications.
- Energy Management system.
- Retrofit Costs/Loan Amount: $374,239

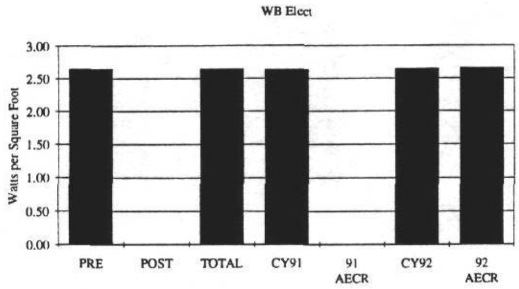
Utilities Unit Costs: $0.02659/kWh, $7.52/MMBtu (CW). Heating is not metered.

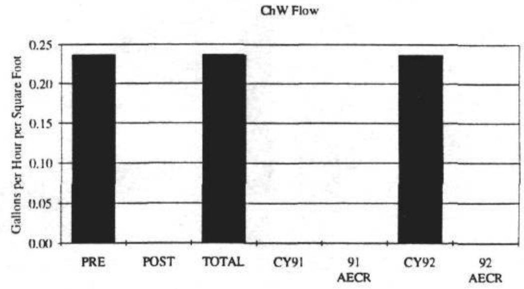
Miscellaneous plots for the Basic Sciences Building:

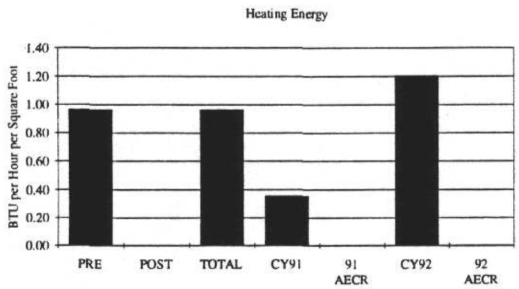


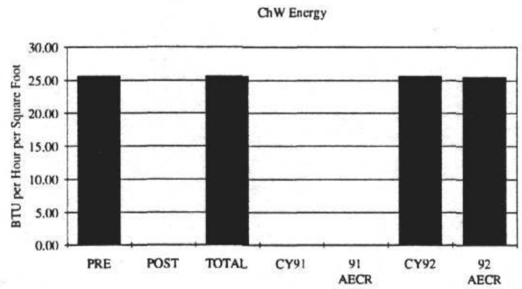


Moody Memorial Building
MLB - 403









Moody Memorial Library
University of Texas Medical Branch - Galveston
Galveston, Texas 77550

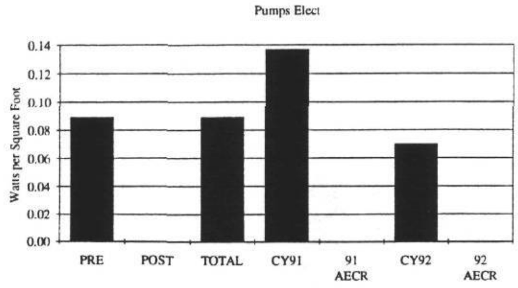
Size: 67,380 square feet
Construction: Face brick and glass structure, flat roof. Erected in 1968.
Lighting: Fluorescent and incandescent.
Utilization: Administrative offices, conference rooms and libraries.

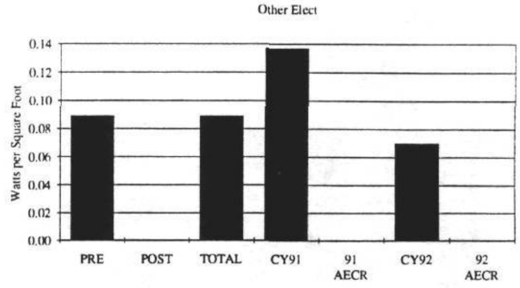
LoanSTAR Monitoring Start Date: June 19, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Solar screening,
- New controls for chilled water pumps,
- Lighting modifications,
- Energy Management system.
- Retrofit Costs/Loan Amount: $55,845

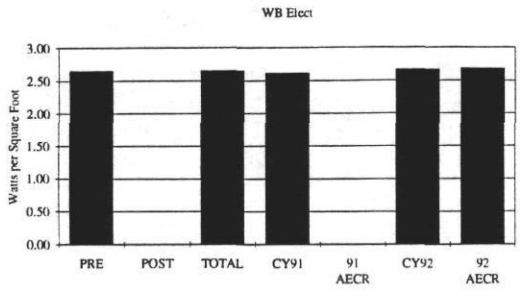
Utilities Unit Costs: $0.02659/kWh, $7.52/MMBtu (CW). Heating is not metered.

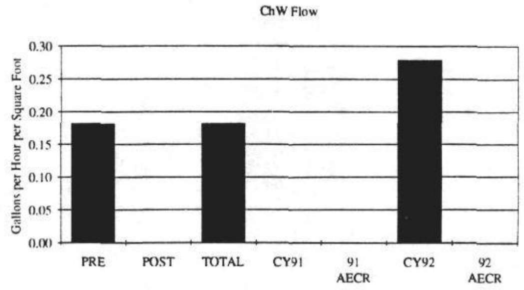
Miscellaneous plots for the Moody Memorial Building:

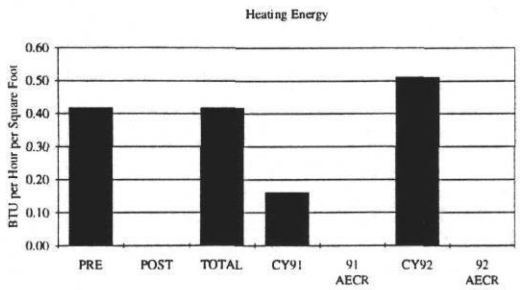


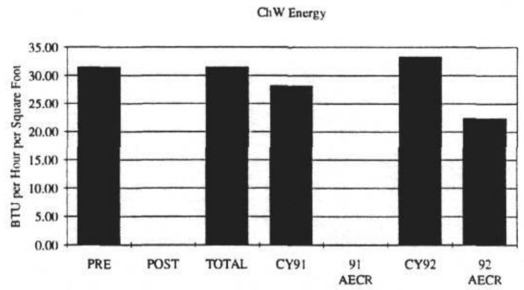


John Sealy South
JSS - 404









John Sealy Towers South
University of Texas Medical Branch - Galveston
Galveston, Texas 77550

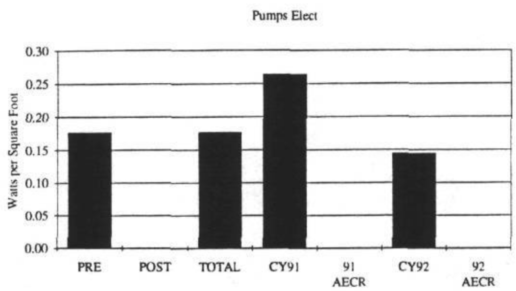
Size: 373,085 square feet
Construction: Light brick facade, windows are 10% of total wall area, flat roof. Erected in 1978.
Lighting: Fluorescent and incandescent.
Utilization: Administrative offices.

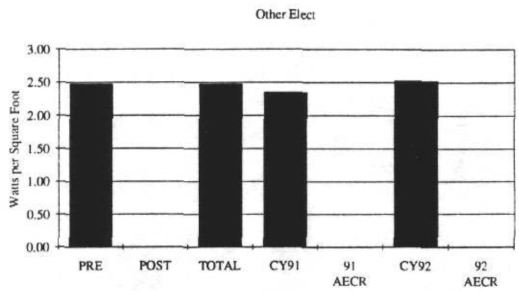
LoanSTAR Monitoring Start Date: June 19, 1991
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Chilled water pump speed controls,
- Lighting modifications,
- Energy management system.
- Retrofit Costs/Loan Amount: $83,256

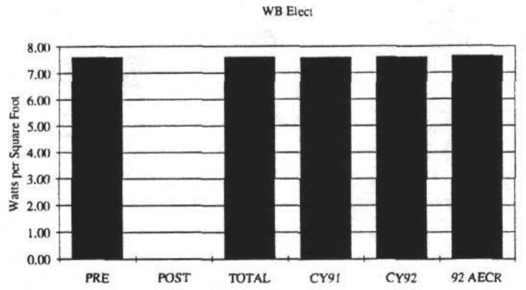
Utilities Unit Costs: $0.02659/kWh, $7.52/MMBtu (CW). Heating is not metered.

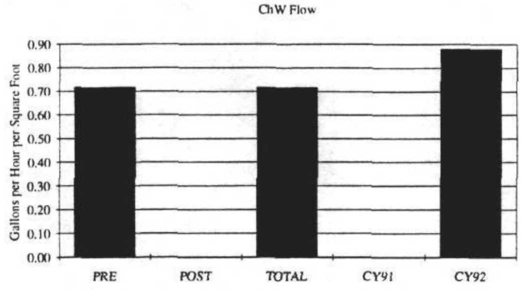
Miscellaneous plots for John Sealy South:

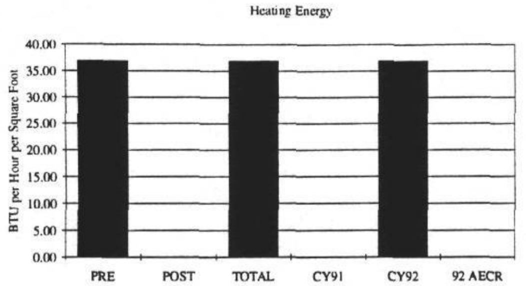


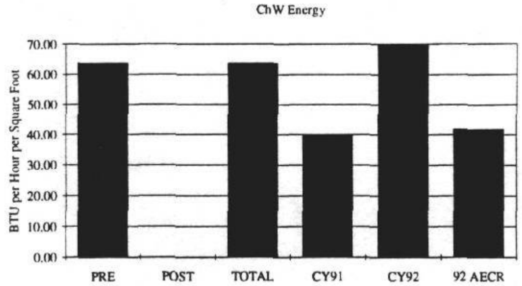


John Sealy North
JSN - 400









John Sealy Tower North
University of Texas Medical Branch - Galveston
Galveston, Texas 77550

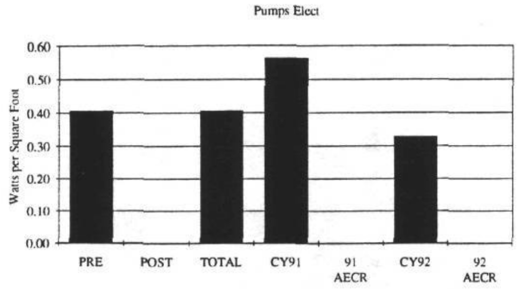
Size: 54,494 feet
Construction: Face brick facade, windows are 5% of total wall area, flat roof. Erected in 1978.
Lighting: Fluorescent (90%) and incandescent (10%).
Utilization: Administrative offices.

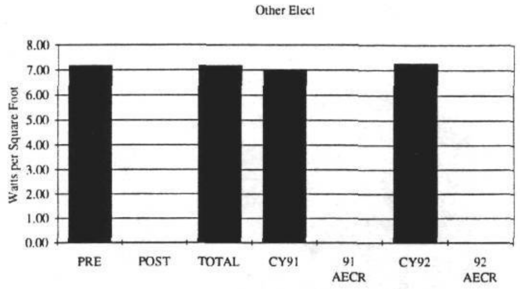
LoanSTAR Monitoring Start Date: June 19, 1991
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Chilled water pumps speed controls
- Lighting modifications,
- Energy management system.
- Retrofit Costs/Loan Amount: $50,880

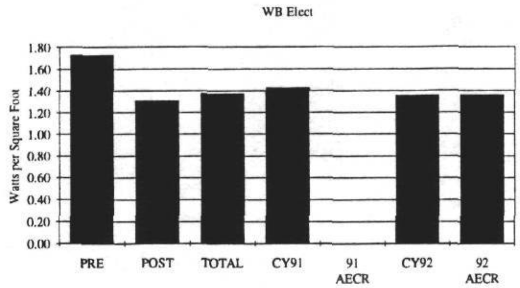
Utilities Unit Costs: $0.02659/kWh, $7.52/MMBtu (CW). Heating is not metered Steam.

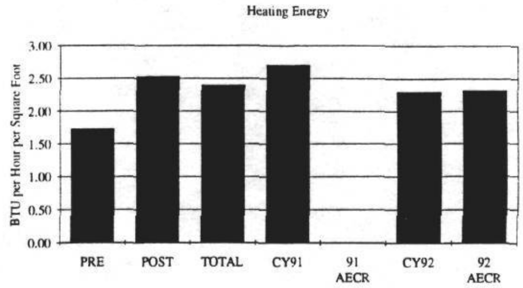
Miscellaneous plots for John Sealy North:





Sims Elementary School
SIM - 128





Sims Elementary School
Fort Worth Independent School District
Fort Worth, Texas 76107

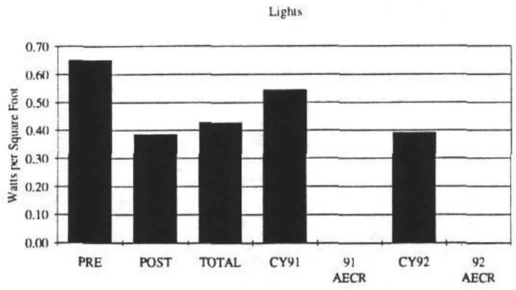
Size: 62,400 square feet
Construction: Face brick, single pane tinted operable windows, built up roof. Erected 1988.
Lighting: Fluorescent.
Utilization: Classrooms and administrative offices.

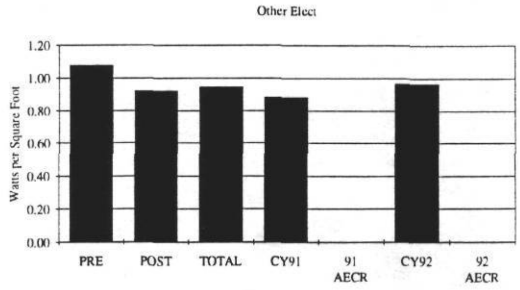
LoanSTAR Monitoring Start Date: September 10, 1991.
Retrofit Start Date: November 23, 1991.
Retrofit Completion Date: November 23, 1991.

Retrofit Information:
- Convert 2 X 4, 4 lamp fixtures to 1 X 4, 2 lamp fixtures.
- Retrofit Costs/Loan Amount: N/A

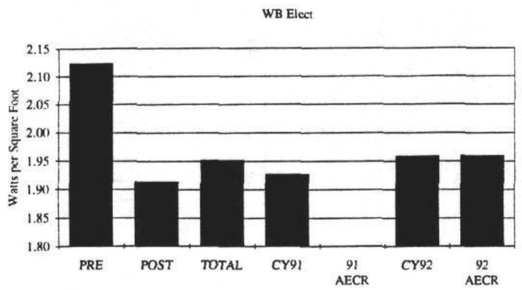
Utilities Unit Costs: $0.06740/kWh and $4.60/MMBtu (Natural Gas). Cooling energy is not metered.

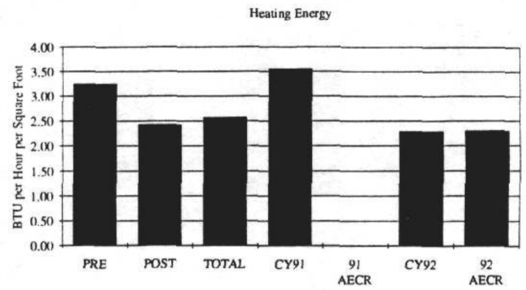
Miscellaneous plots for Sims Elementary School:





Dunbar Middle School
DMS - 129





Dunbar Middle School
Fort Worth Independent School District
Fort Worth, Texas 76107

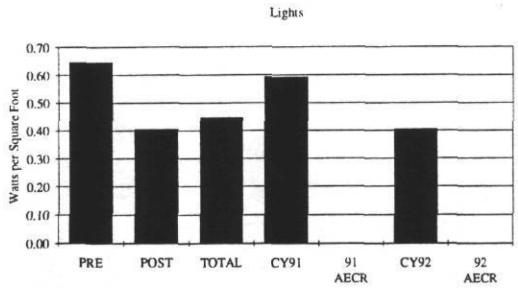
Size: 92,886 square feet
Construction: Face brick, single pane windows, built up roof. Erected in 1982.
Lighting: Fluorescent.
Utilization: Classrooms and administrative offices.

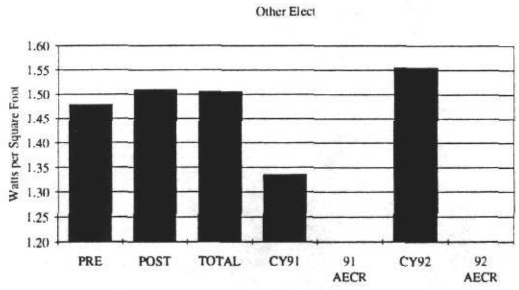
LoanSTAR Monitoring Start Date: September 17, 1991.
Retrofit Start Date: December 9, 1991.
Retrofit Completion Date: December 9, 1991.

Retrofit Information:
- Convert 2 X 4, 6 lamp fixtures to 1 X 4, 2 lamp fixtures.
- Retrofit Costs/Loan Amount: N/A

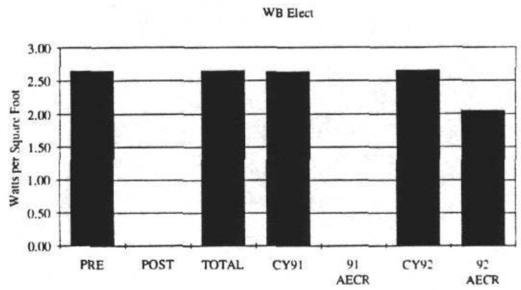
Utilities Unit Costs: $0.06740/kWh and $4.60/MMBtu (Natural gas. Cooling energy is not metered.

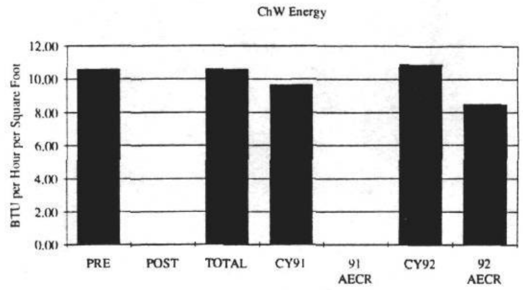
Miscellaneous plots for Dunbar Middle School:





University of Texas Pan Am
UTP - 125





University of Texas Pan-American
Edinburg, Texas 78539

Size: 1,173,952 square feet
Construction: Twenty five individual building with brick veneer. Erected in 1970
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, and lecture halls.

LoanSTAR Monitoring Start Date: September 3, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

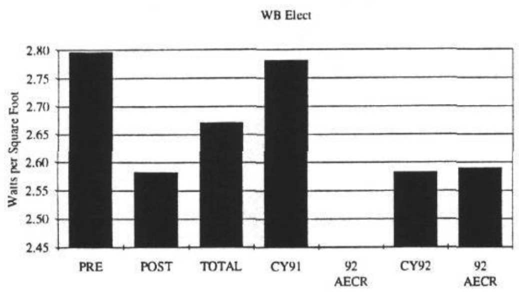
Retrofit Information:
- Motion sensors and delamping,.
- Install adjustable frequency drives on AHUs and chilled water pumps,
- Replace thermostats with non adjustable thermostat.
- Retrofit Costs/Loan Amount: $738,482

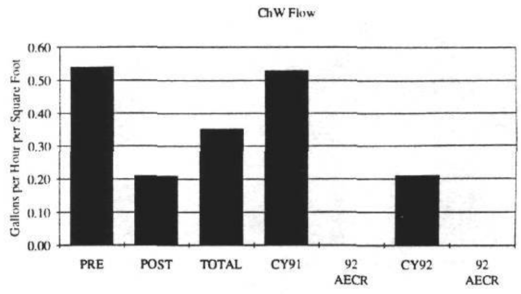
Utilities Unit Costs: $0.02820/kWh, $6.00/MMBtu (CW). Heating is not metered.

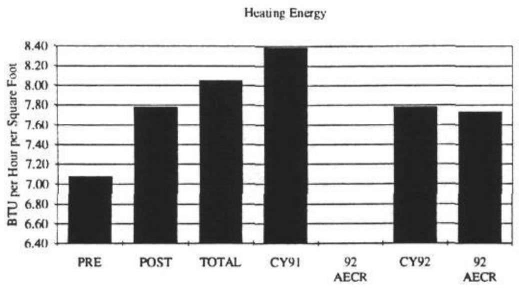
Miscellaneous plots:

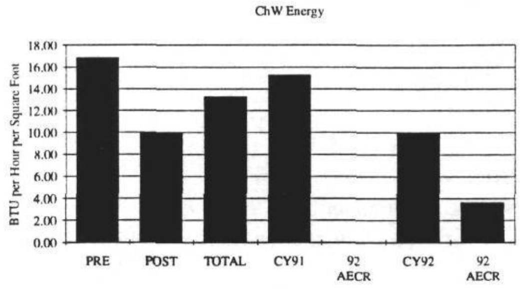
NONE.

Texas Department of Health
TDH - 130









Texas Department of Health
Austin, Texas 78756

Size: 284,000 square feet
Construction: Multiple building. Erected in 1958 and 1976 time frame.
Lighting: unknown.
Utilization: Administrative offices and labs.

LoanSTAR Monitoring Start Date: February 15, 1991.
Retrofit Start Date: September 1, 1991.
Retrofit Completion Date: March 16, 1992.

Retrofit Information:

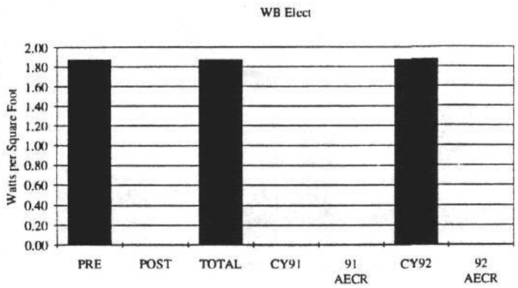
- Unknown.
- Retrofit Costs/Loan Amount: $289,174

Utilities Unit Costs: $0.03915/kWh, $3.25/MMBtu (CW), and $3.84/MMBtu (Natural Gas).

Miscellaneous plots:

NONE.

University of Texas at Dallas
UTD - 137



University of Texas at Dallas
Dallas, Texas

Size: 481,549 square feet
Construction: Unknown.
Lighting: Fluorescent.
Utilization: Administrative offices and Classrooms.

LoanSTAR Monitoring Start Date: August 29, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

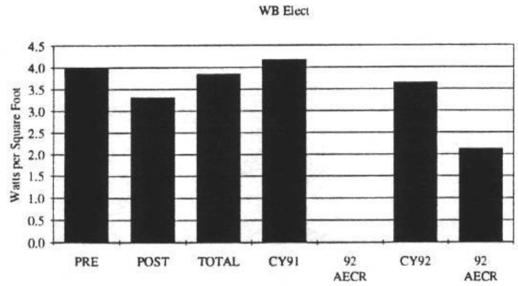
Retrofit Information:
- Unknown.
- Retrofit Costs/Loan Amount: $766,201

Utilities Unit Costs: Unknown.

Miscellaneous plots:

NONE.

Texas College of Osteopathic Medicine
COM - 138



Texas College of Osteopathic Medicine
Fort Worth, Texas 76107

Size: 261,000 square feet
Construction: Performed concrete panel exterior with insulation, single pane gray windows with interior blinds.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, labs and college library.

LoanSTAR Monitoring Start Date: August 13, 1991.
Retrofit Start Date: June 30, 1992.
Retrofit Completion Date: June 30, 1992

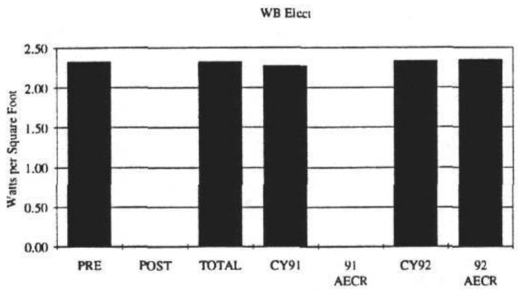
Retrofit Information:
- Unknown.
- Retrofit Costs/Loan Amount: $168,213

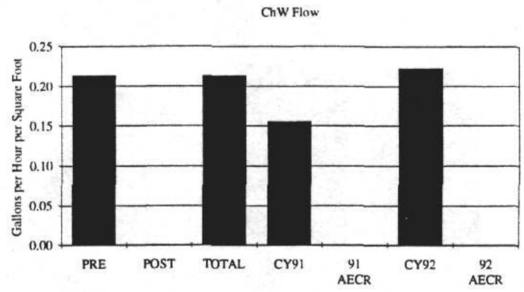
Utilities Unit Costs: $0.031/kWh. Cooling and Heating is not metered.

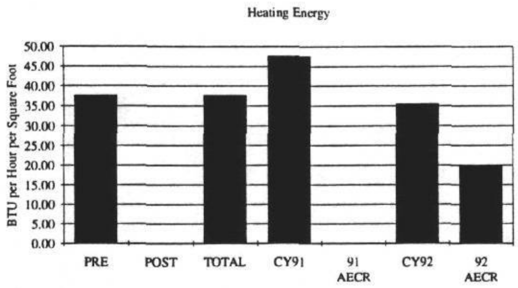
Miscellaneous plots:

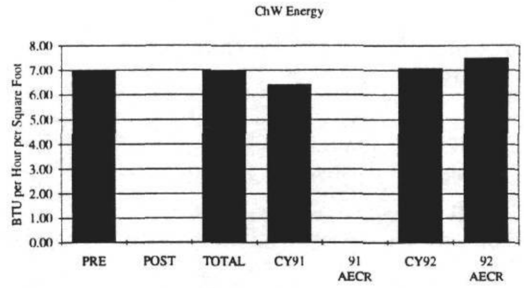
NONE.

Texas A&M University at Galveston
TAG - 139









Texas A&M University at Galveston
Galveston, Texas 77553

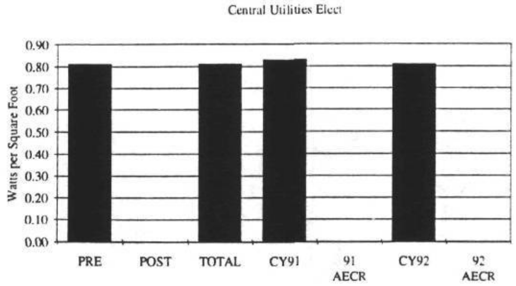
Size: 382,232 square feet
Construction: Nine buildings with textured concrete exteriors.
Lighting: Fluorescent and incandescent.
Utilization: Classrooms, administrative offices, dormitories and library.

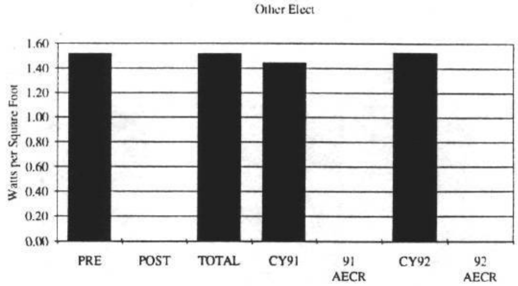
LoanSTAR Monitoring Start Date: November 12, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Programmable timers,
- Fluorescent retrofit in dorms,
- Variable speed drives.
- Retrofit Costs/Loan Amount: $88,589

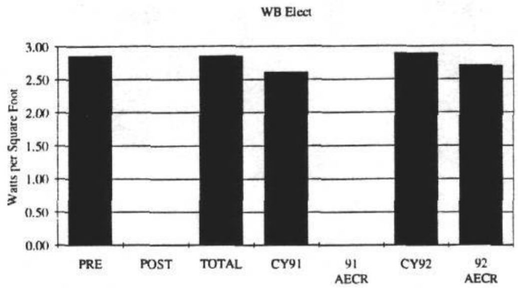
Utilities Unit Costs: $0.0286/kWh, $6.00/MMBtu (CW), and $2.33/MMBtu (Natural Gas).

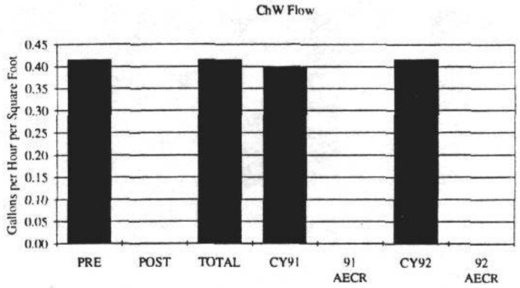
Miscellaneous plots for Texas A&M University at Galveston:

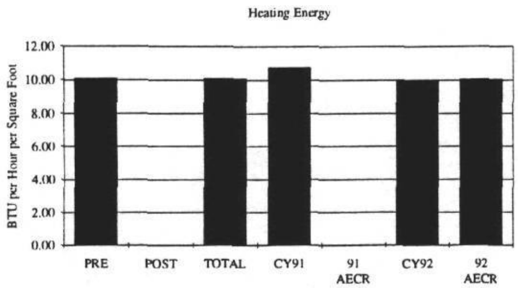


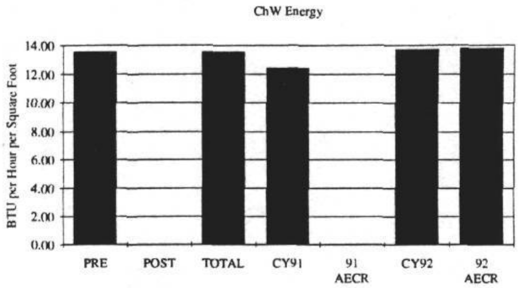


Delmar College
DMC - 143









Delmar College
Corpus Cristi, Texas 78404

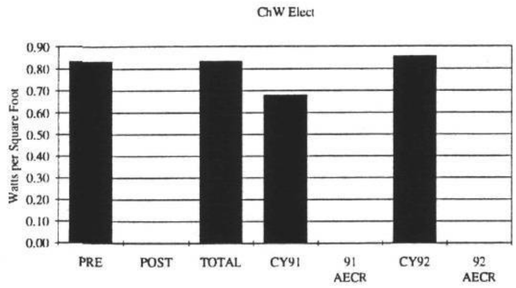
Size: 681,592 square feet
Construction: Twenty three building, variable construction. Built in 1940 to present.
Lighting: Fluorescent and incandescent.
Utilization: Classrooms and administrative offices.

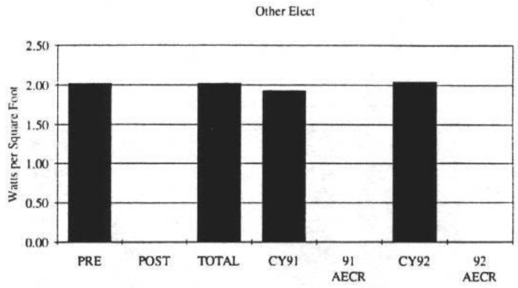
LoanSTAR Monitoring Start Date: November 12, 1991.
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

Retrofit Information:
- Thermal energy storage/ industrial water source heat pump,
- Capacitors for power factor improvement,
- Lighting controls,
- Fixture relamping.
- Retrofit Costs/Loan Amount: $1,157,404

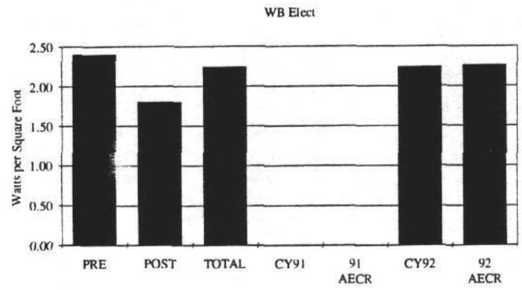
Utilities Unit Costs: $0.02940/kWh, $6.00/MMBtu (CW), and $3.94/MMBtu (Natural Gas).

Miscellaneous plots for Delmar College:





Midland County Courthouse
MCC-144



Midland County Courthouse
Midland , Texas 79701

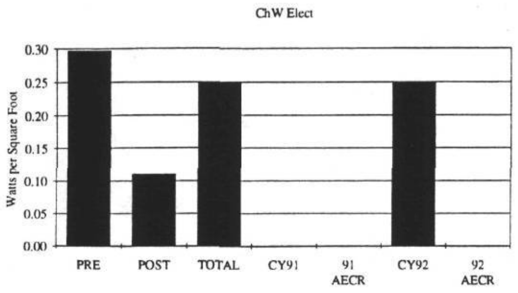
Size: 90,100 square feet
Construction: Exterior plaster walls, single pane tinted windows, flat roof. Erected in 1930
Lighting: Fluorescent.
Utilization: Administrative offices, court rooms and jail.

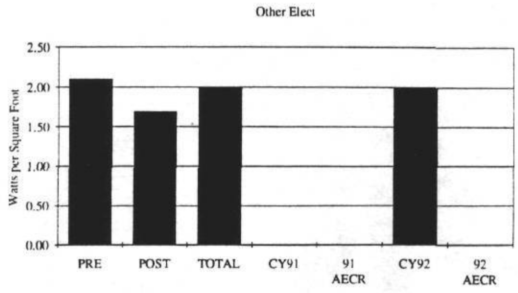
LoanSTAR Monitoring Start Date: January 7, 1992.
Retrofit Start Date: September 30, 1992.
Retrofit Completion Date: September 30, 1992.

Retrofit Information:
- Energy management system,
- Occupancy sensors,
- Electronic ballast's,
- Modify chiller piping and control.
- Retrofit Costs/Loan Amount: $192,902

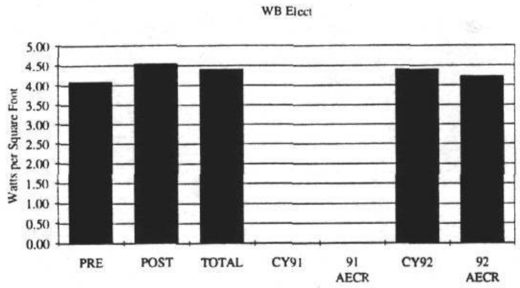
Utilities Unit Costs: $0.0300/kWh. Cooling and heating is not metered.

Miscellaneous plots for the Midland County Courthouse:





Ward Memorial Hospital
WMH - 145



Ward Memorial Hospital
Monahams, Texas 79756

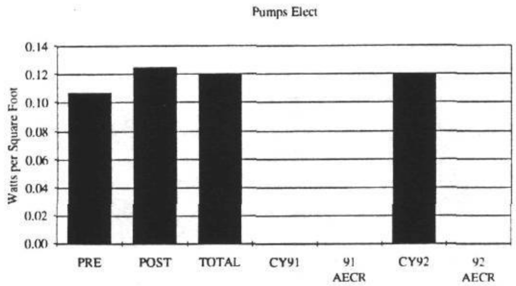
Size: 37,000 square feet
Construction: Unknown
Lighting: Fluorescent.
Utilization: Administrative offices, labs, clinics etc.

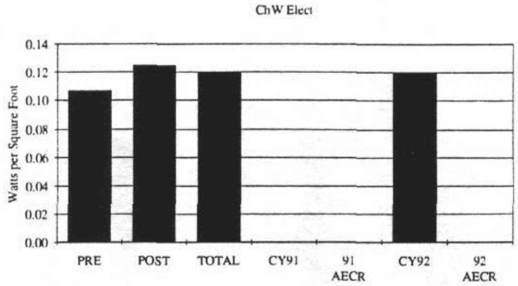
LoanSTAR Monitoring Start Date: January 16, 1992.
Retrofit Start Date: April 30, 1992.
Retrofit Completion Date: April 30, 1992.

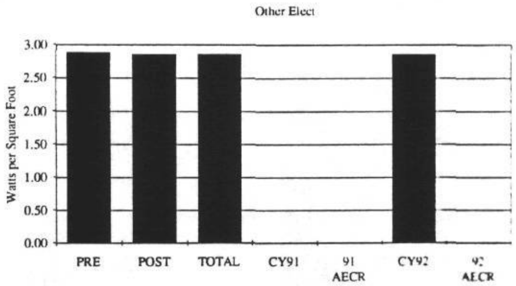
Retrofit Information:
- Unknown.
- Retrofit Costs/Loan Amount: $64,616

Utilities Unit Costs: $0.02630. Cooling and heating is not metered.

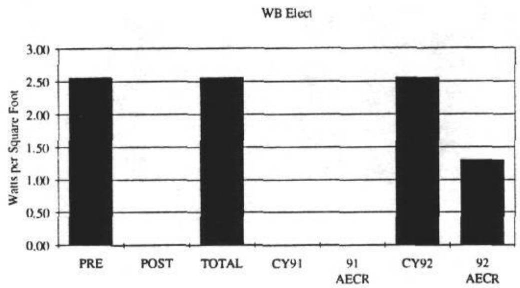
Miscellaneous plots for Ward Memorial Hospital:

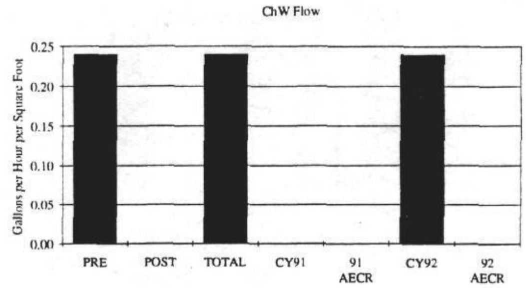


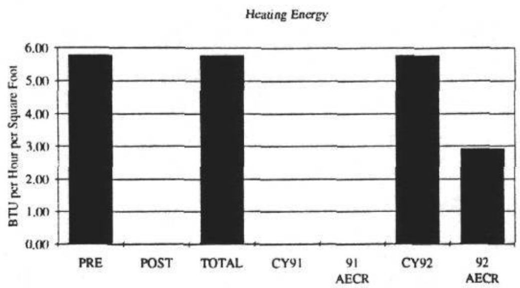


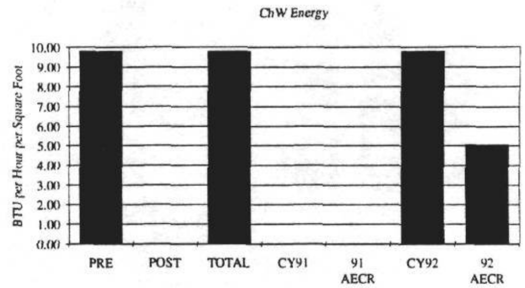


Dallas County Government Center
DCG - 146









Dallas County Government Center
Dallas, Texas 75202

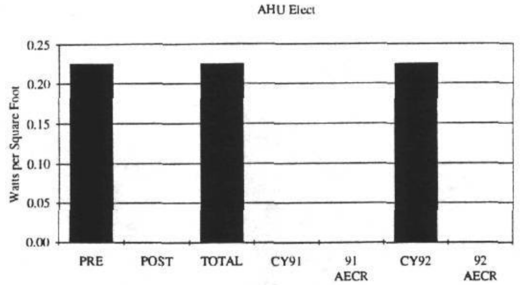
Size: 473,800 square feet
Construction: Steel and concrete structure with marble facie. Erected in 1966.
Lighting: Fluorescent and incandescent.
Utilization: Administrative offices, court rooms and jail.

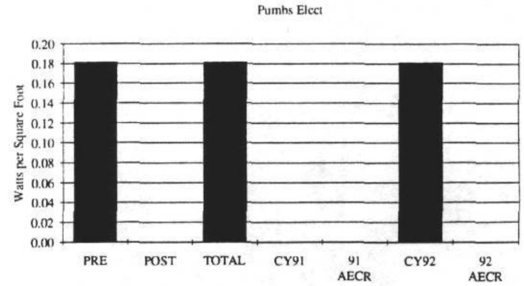
LoanSTAR Monitoring Start Date: June 30, 1992
Retrofit Start Date: N/A.
Retrofit Completion Date: N/A.

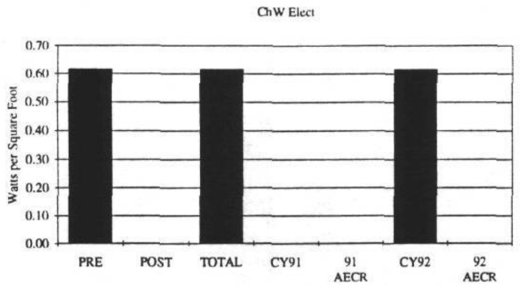
Retrofit Information:
- Delamp fixtures and replacement with fluorescent,
- Install motion sensors to control lighting,
- Energy management system upgrade,
- Install VFRs on chilled water pumps.
- Retrofit Costs/Loan Amount: $643,402

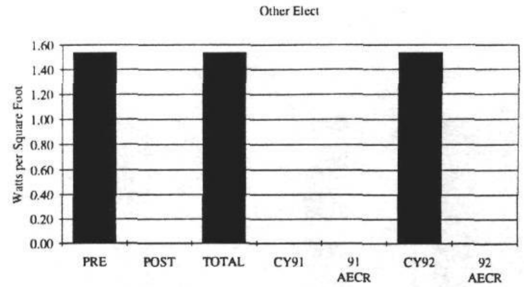
Utilities Unit Costs: $0.02854/kWh, $3.36/MMBtu (CW), and $4.09/MMBtu (Natural Gas).

Miscellaneous plots for the Dallas County Government Center:

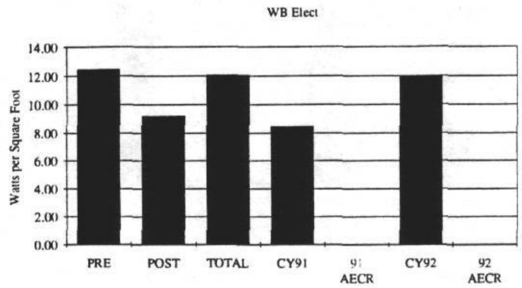


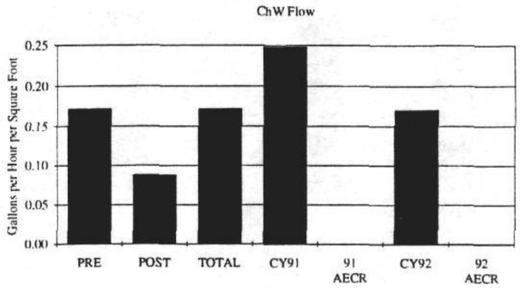


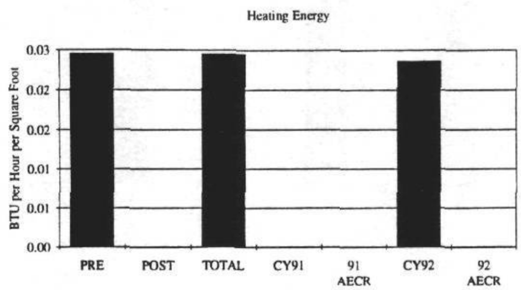


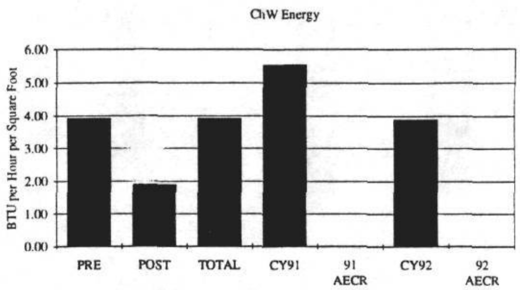


South West Texas State University
SWT - 149









South West Texas State University

Size: 637,223 square feet
Construction: Unknown.
Lighting: Fluorescent.
Utilization: Classrooms, administrative offices, and lecture halls.

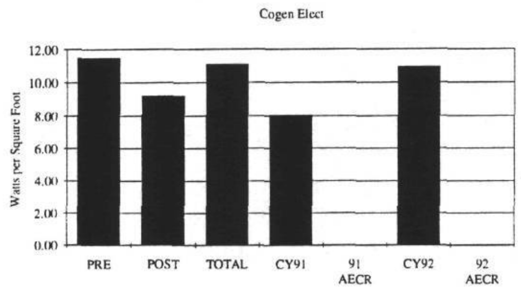
LoanSTAR Monitoring Start Date: January 14, 1992.
Retrofit Start Date: October 31, 1992.
Retrofit Completion Date: October 31, 1992.

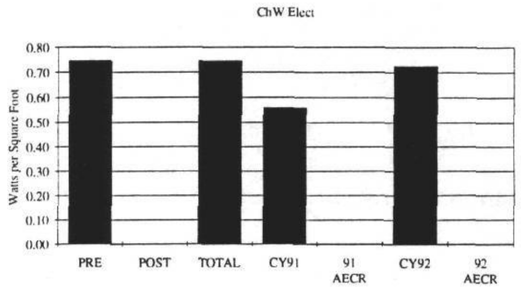
Retrofit Information:

- Unknown.
- Retrofit Costs/Loan Amount: $1,252,088

Utilities Unit Costs: Unknown.

Miscellaneous plots for South West Texas State University:



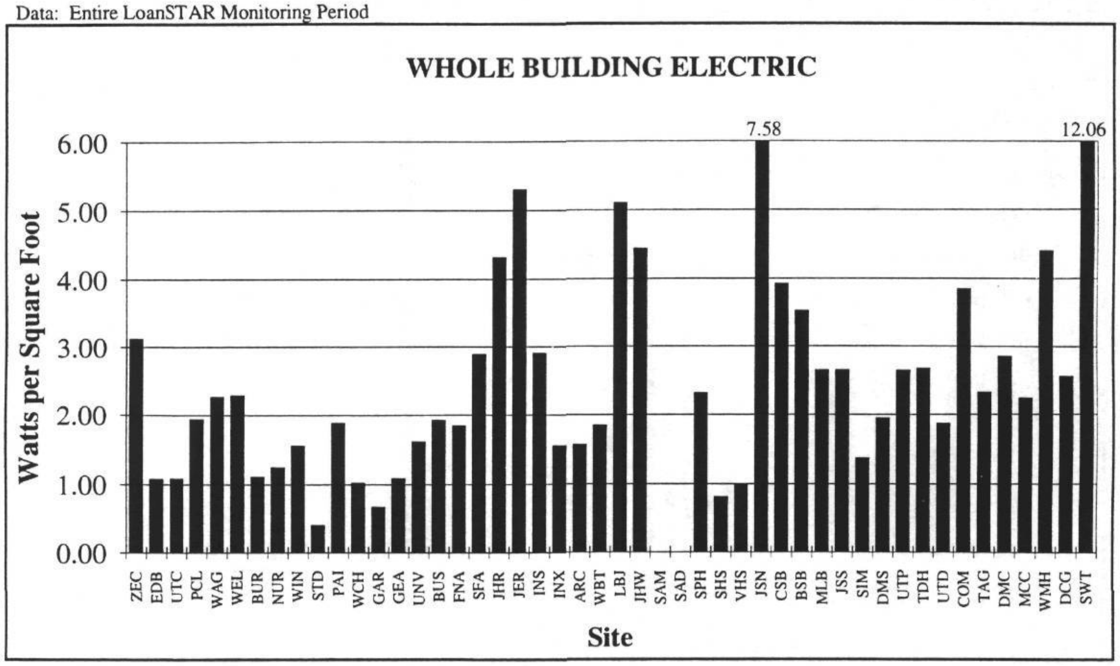


Summary Plots for each LoanSTAR Monitoring Period

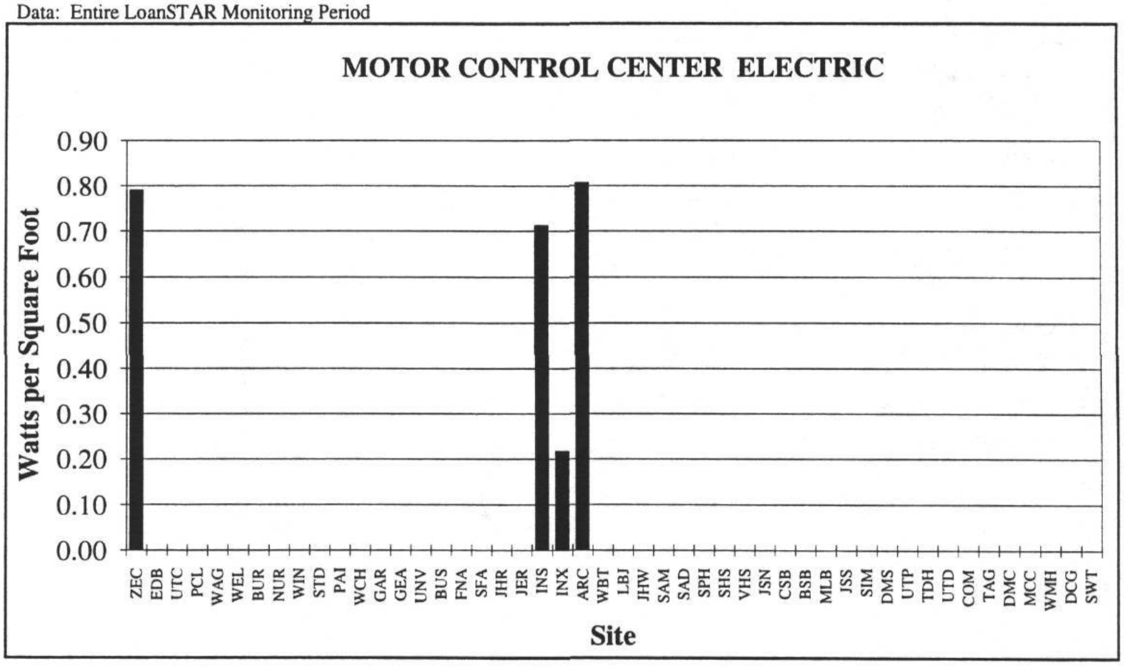
The following pages contain the summary plots of the individual energy utilization index or EUIs for each site. Each plot represents one data monitoring category and one monitoring period. These plots can be utilized to view the energy consumption across the various sites under the LoanSTAR program. Sites with an EUI much higher or much lower than the majority of the other sites should be investigated to determine if a metering problem exists or if the site is a good candidate for a future energy conservation retrofit or an operation & maintenance change.

Total LoanSTAR Monitoring Period Data Plots

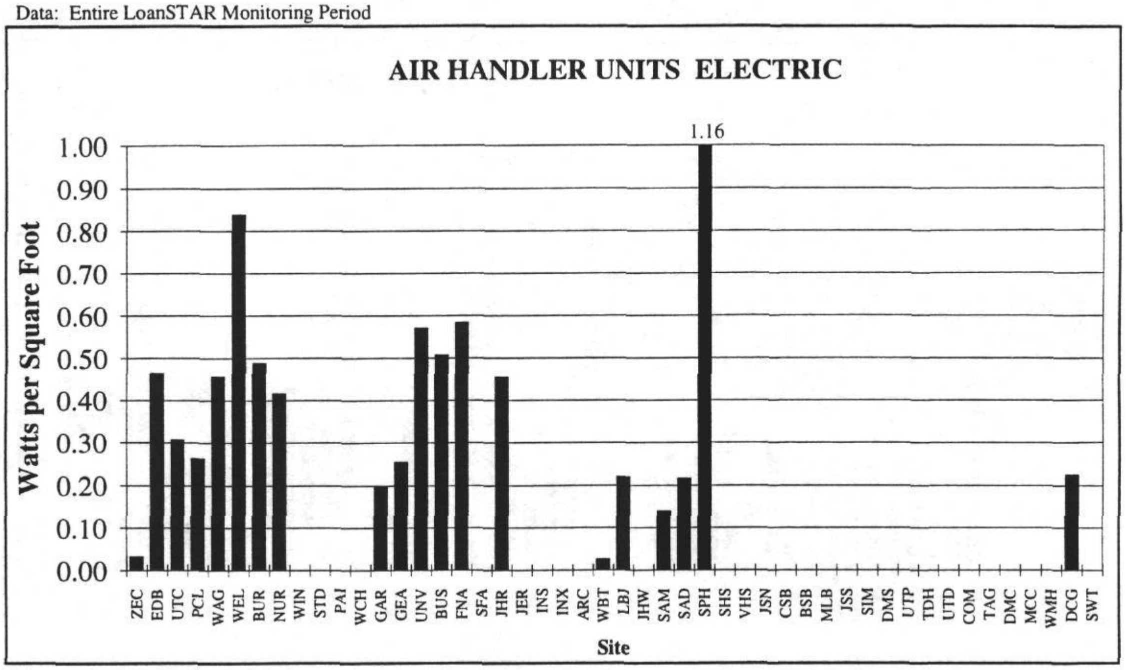
Data: Entire LoanSTAR Monitoring Period



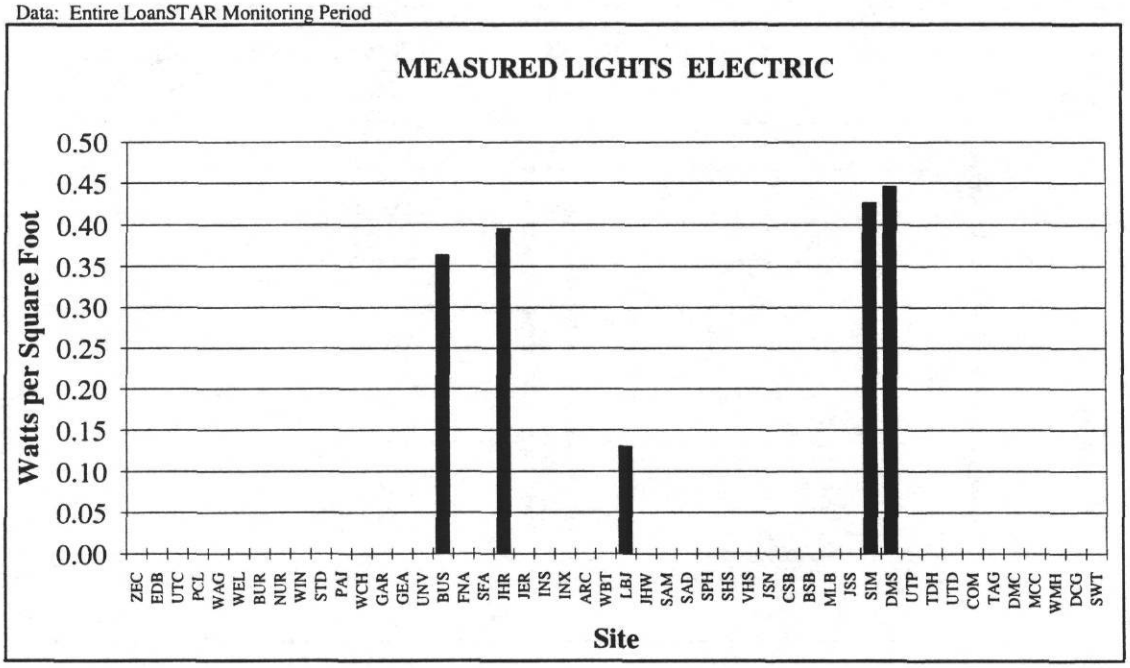
Data: Entire LoanSTAR Monitoring Period



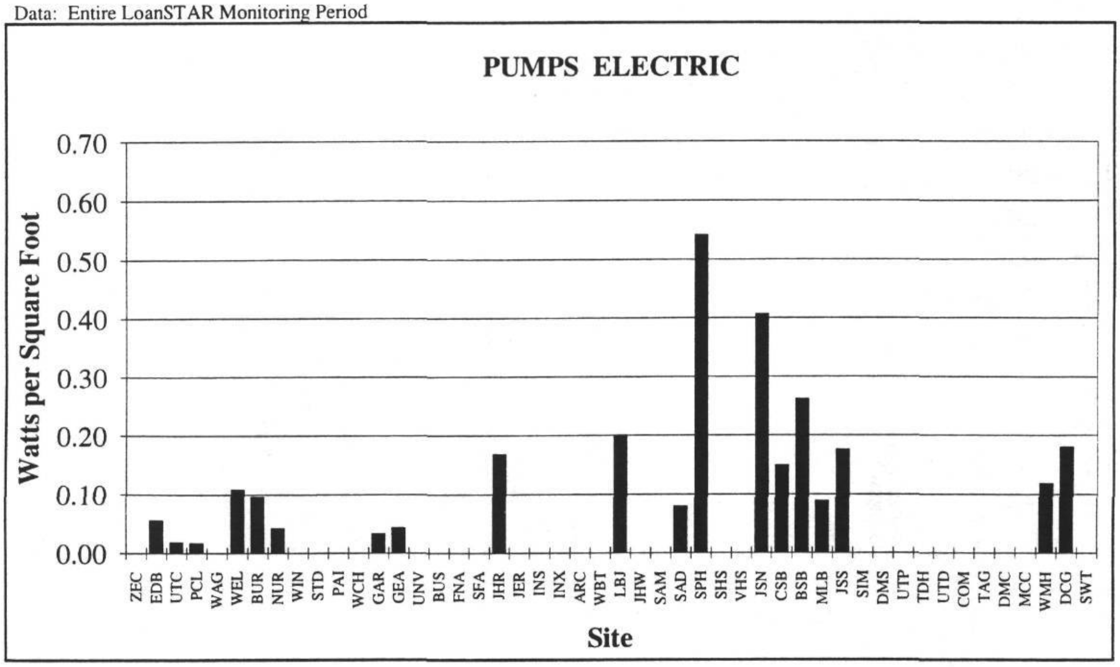
Data: Entire LoanSTAR Monitoring Period



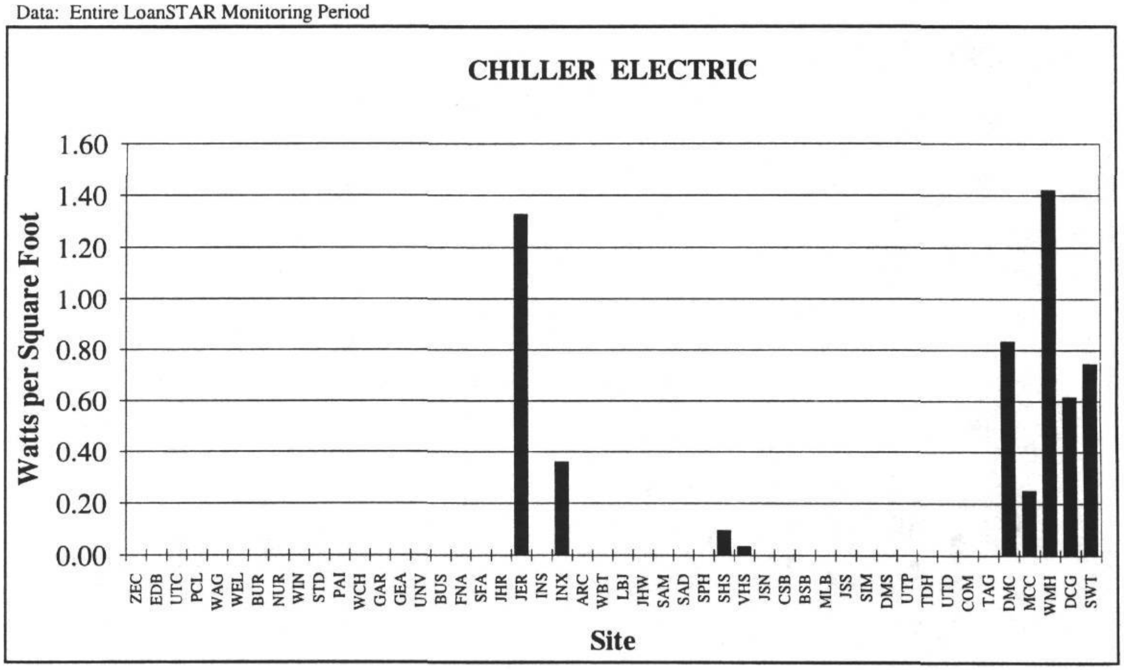
Data: Entire LoanSTAR Monitoring Period



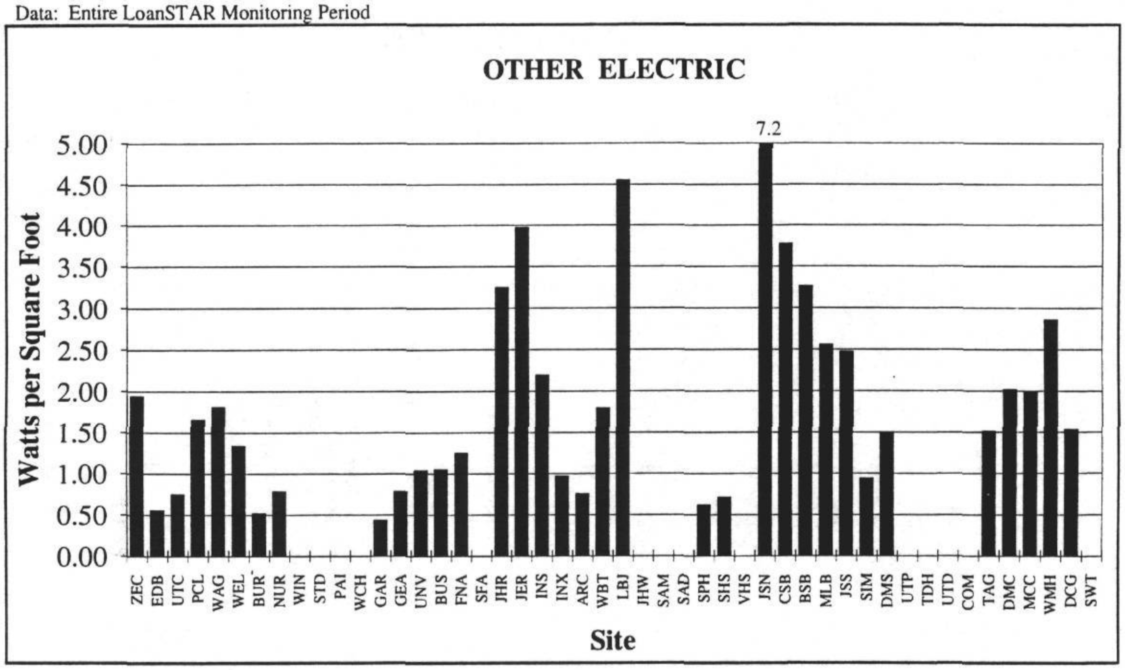
Data: Entire LoanSTAR Monitoring Period



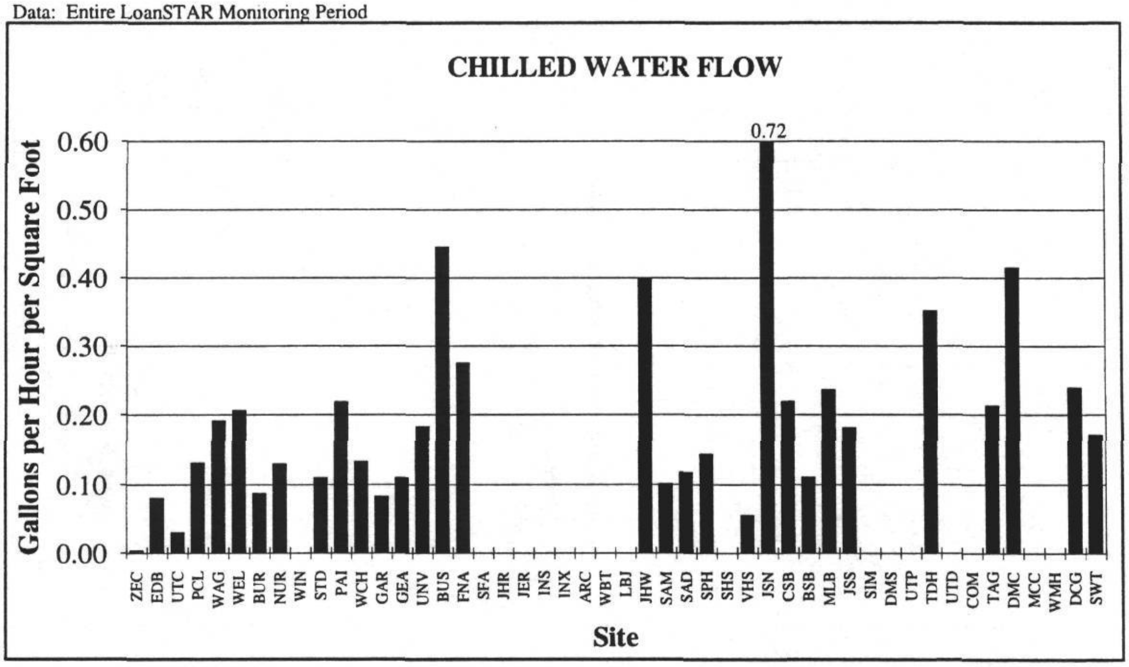
Data: Entire LoanSTAR Monitoring Period



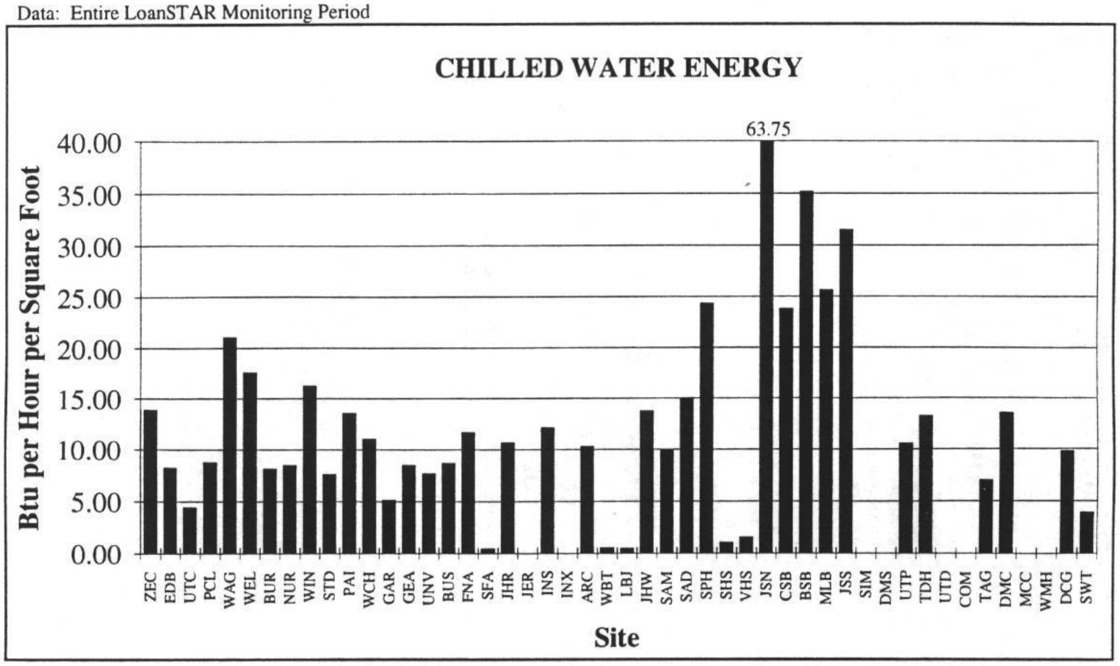
Data: Entire LoanSTAR Monitoring Period



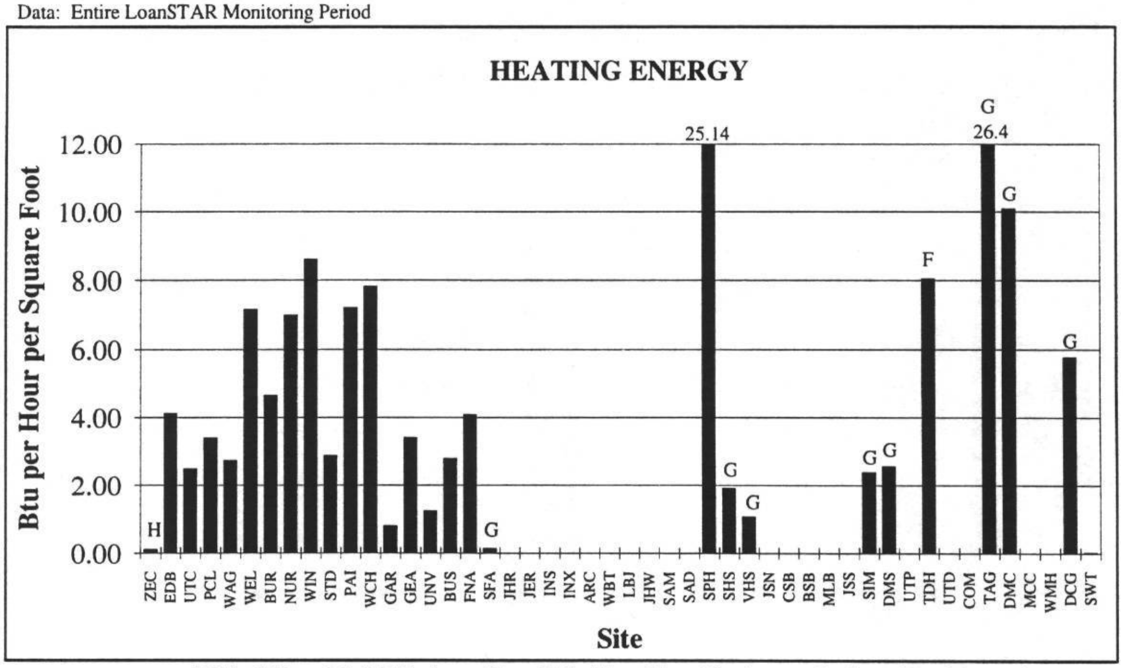
Data: Entire LoanSTAR Monitoring Period



Data: Entire LoanSTAR Monitoring Period



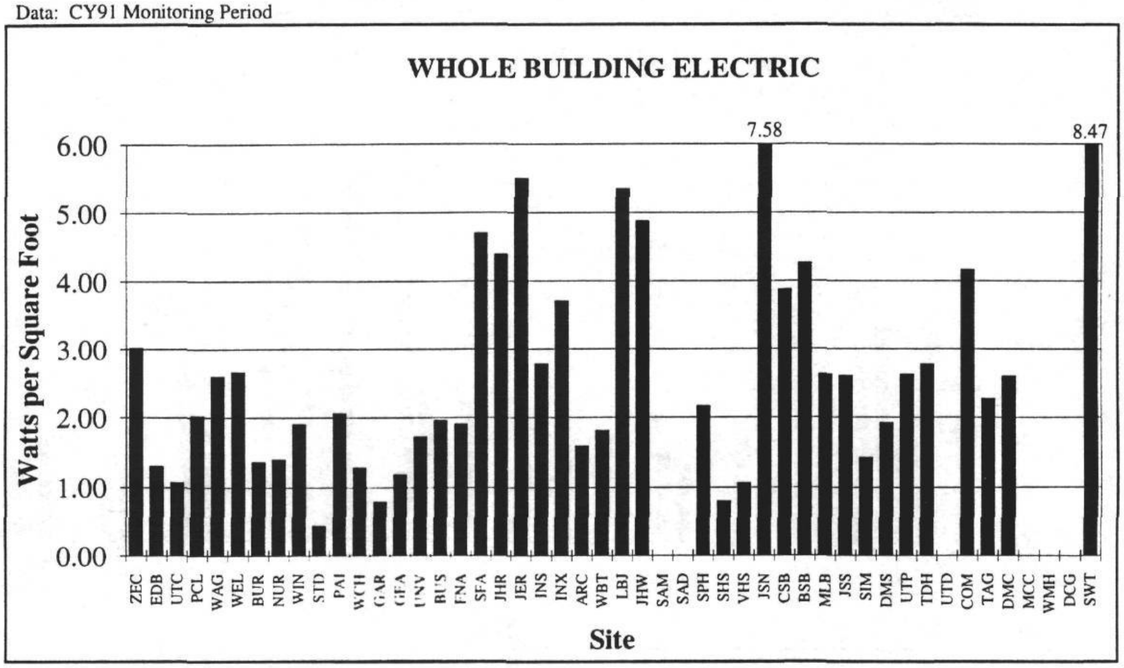
Data: Entire LoanSTAR Monitoring Period



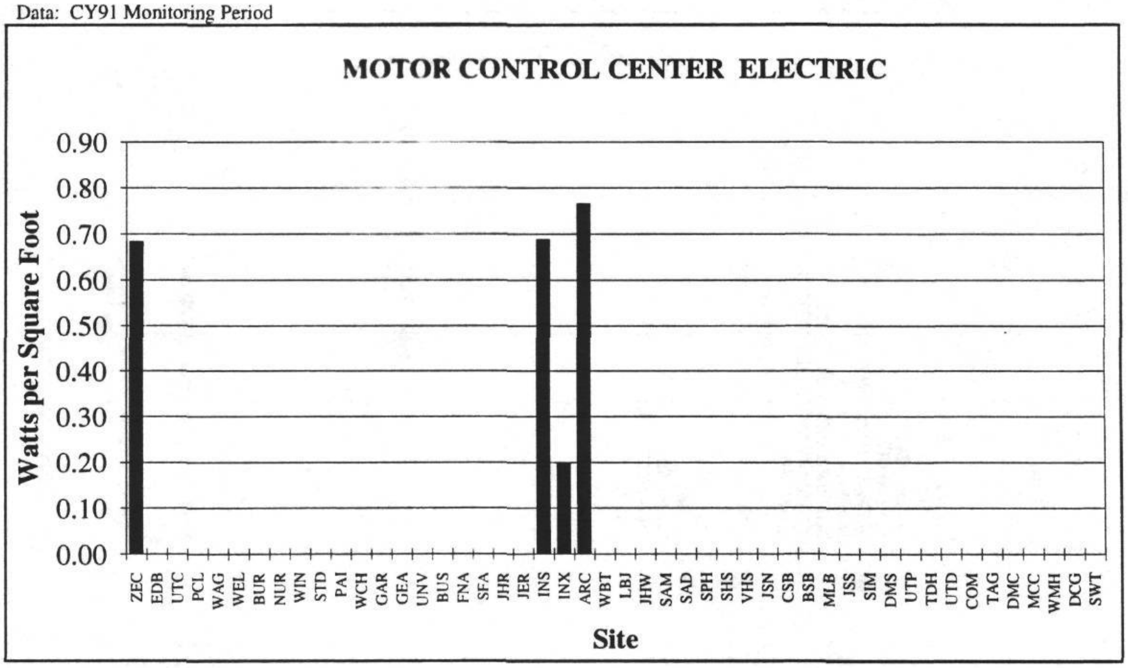
KEY: G-Natural GaS, F-Feedwater Flow, H-Hot Water Flow, All others are Condesate Flow Measured

Calendar Year 1991 Monitoring Period Data Plots

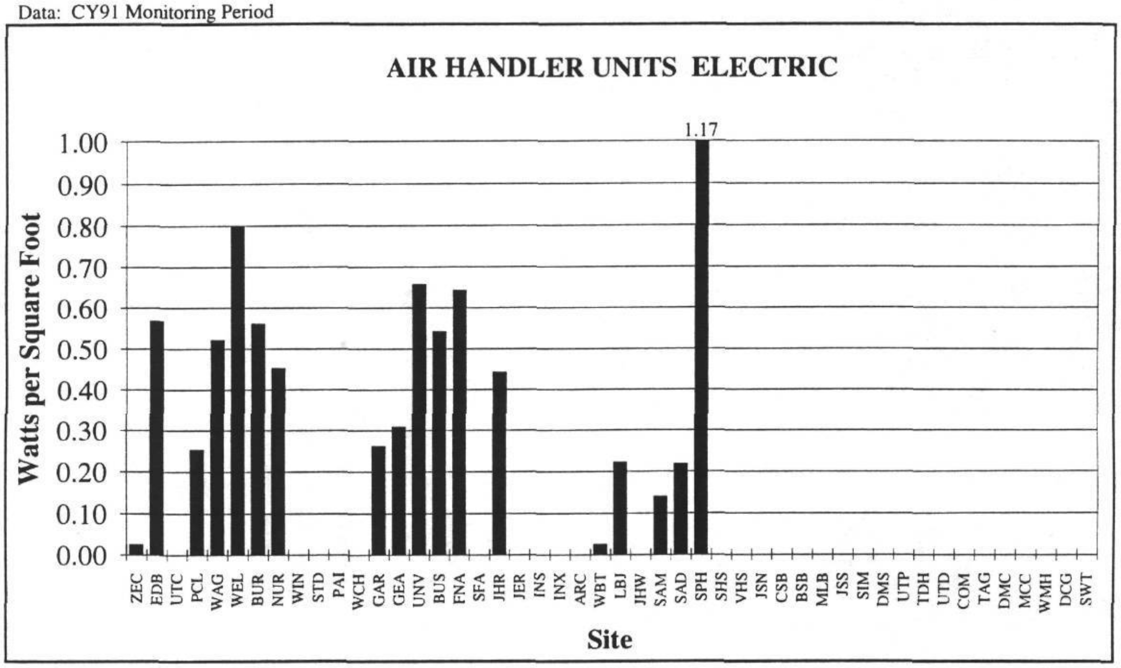
Data: CY91 Monitoring Period



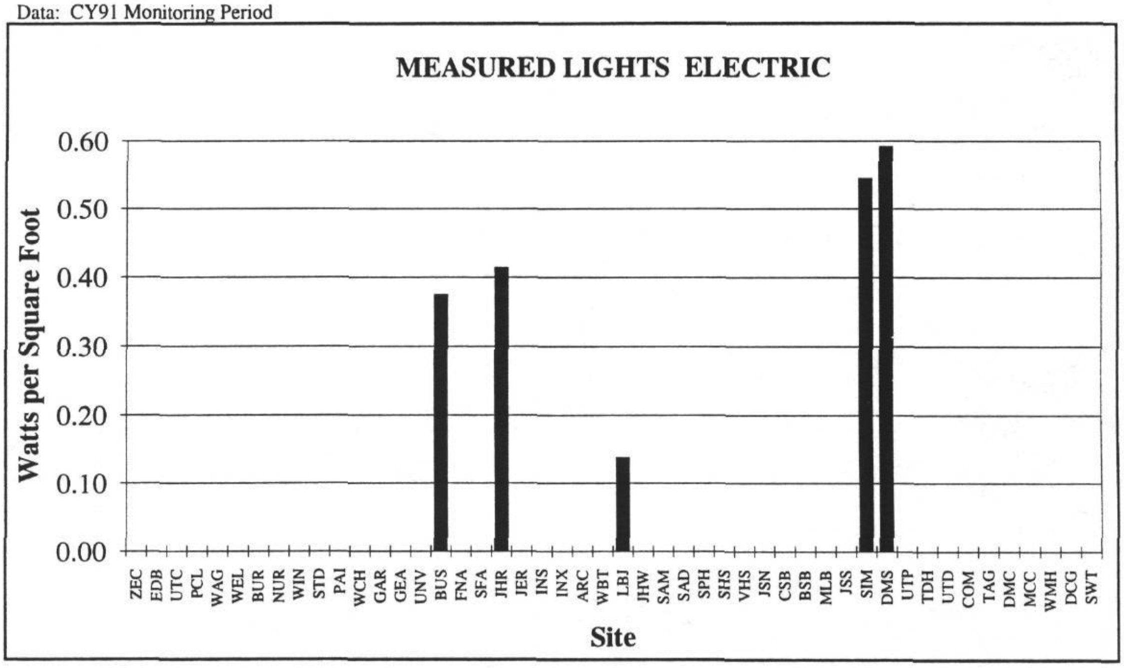
Data: CY91 Monitoring Period



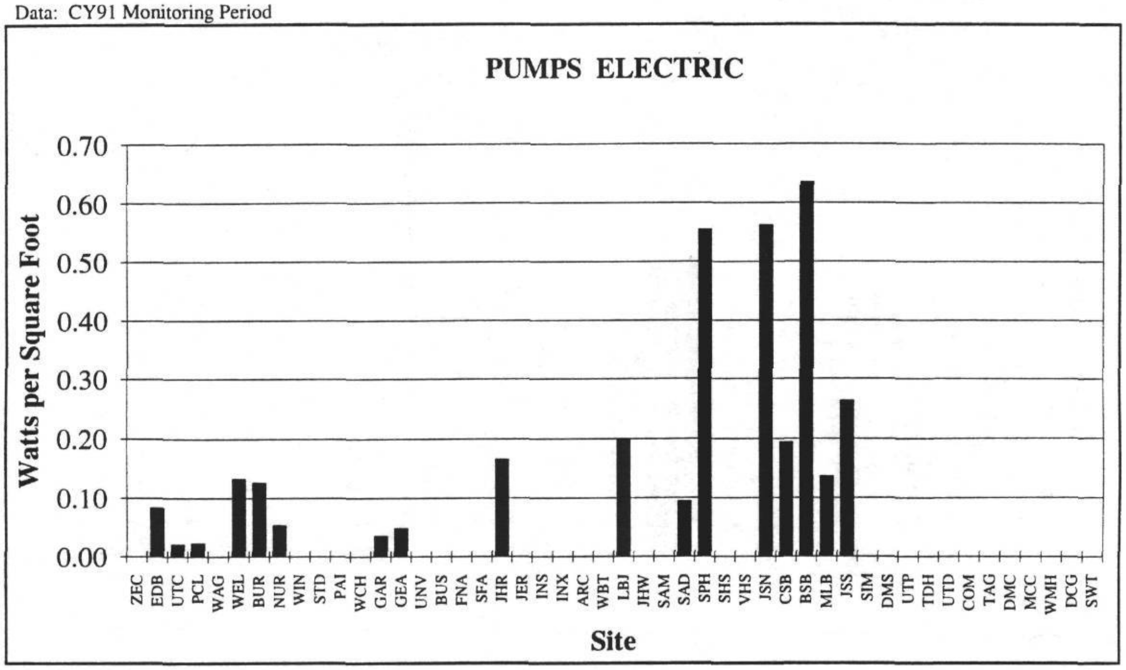
Data: CY91 Monitoring Period



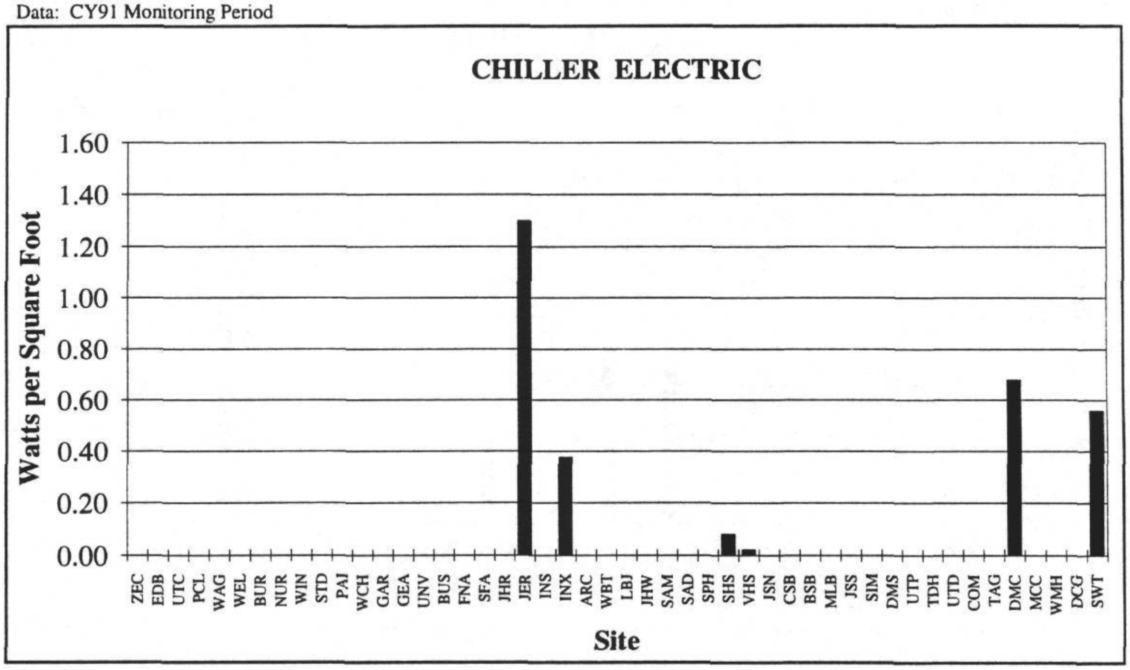
Data: CY91 Monitoring Period



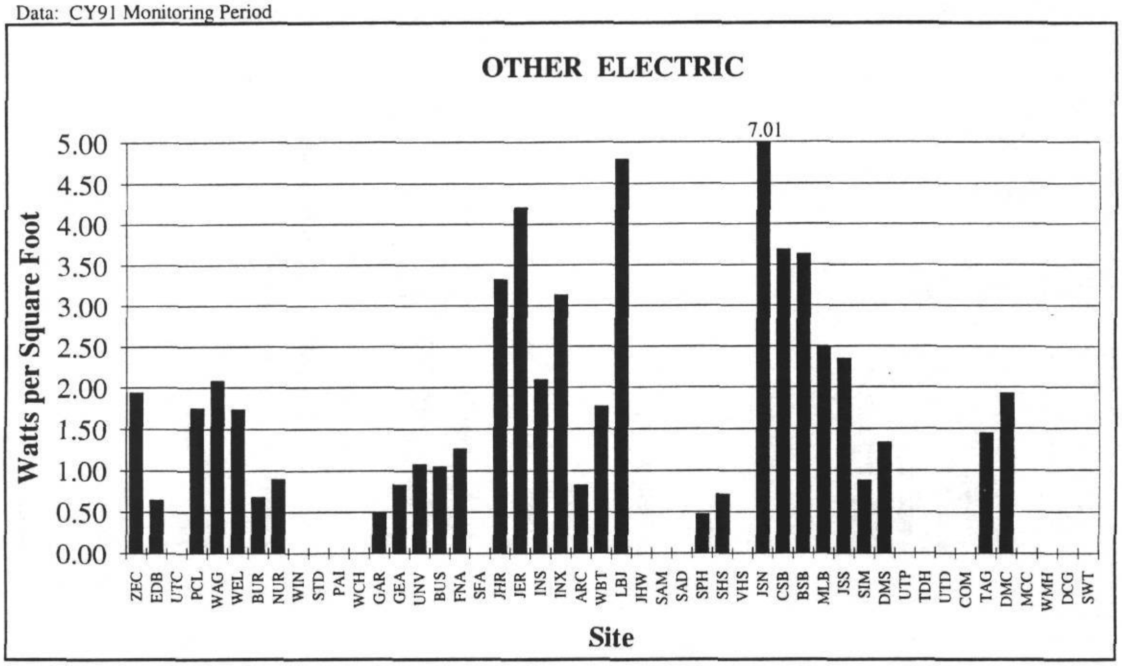
Data: CY91 Monitoring Period



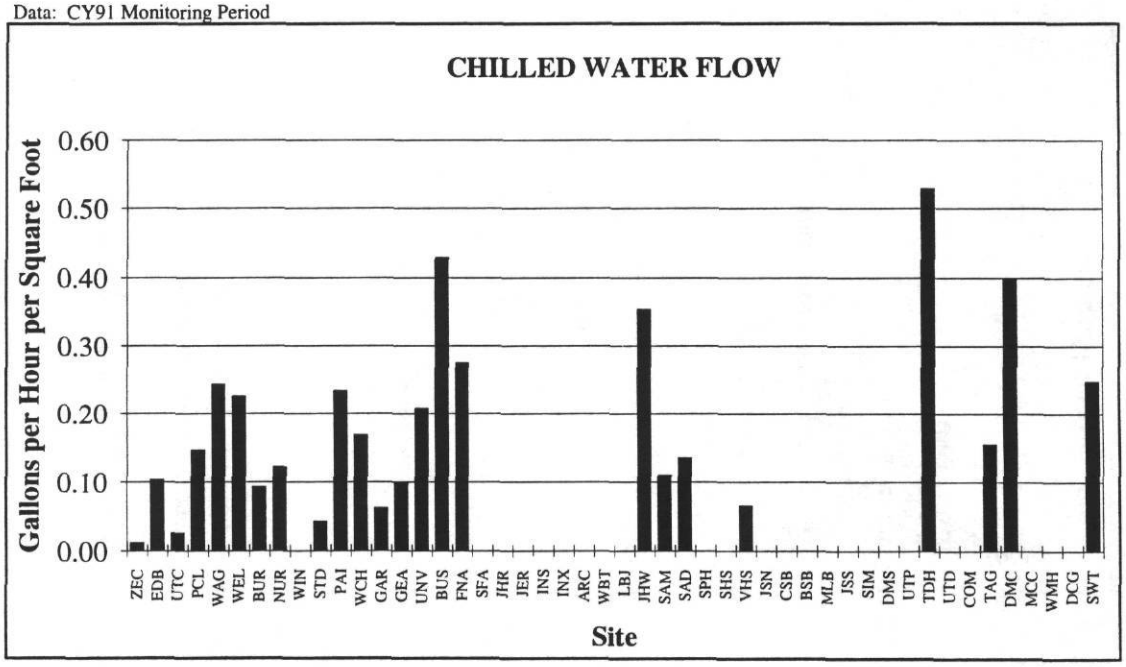
Data: CY91 Monitoring Period



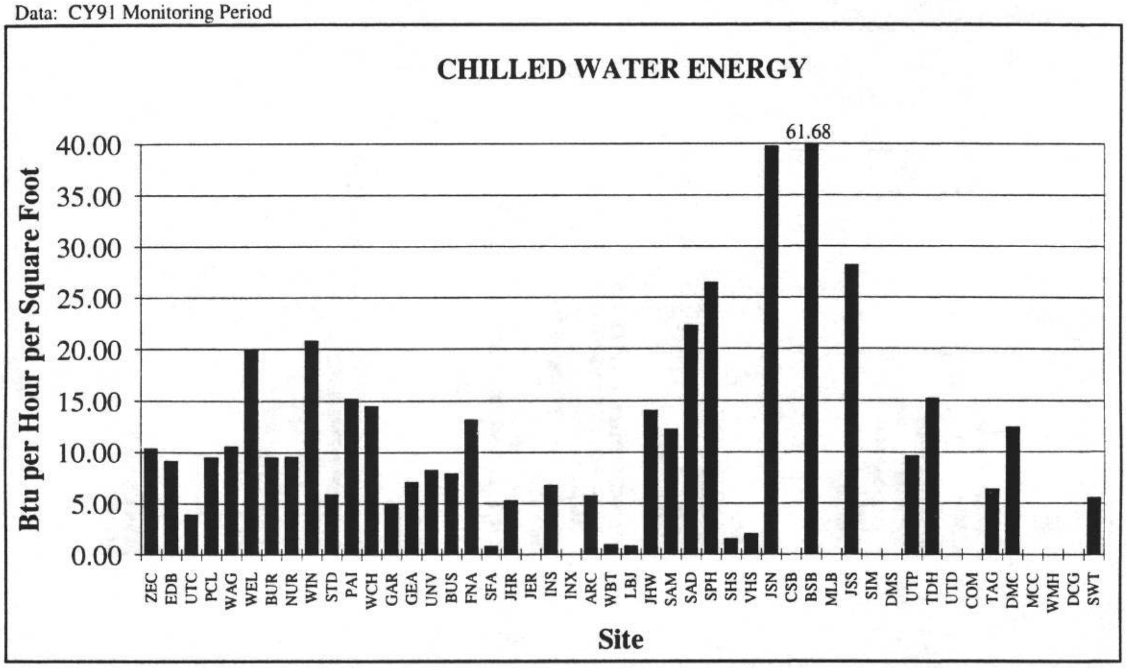
Data: CY91 Monitoring Period



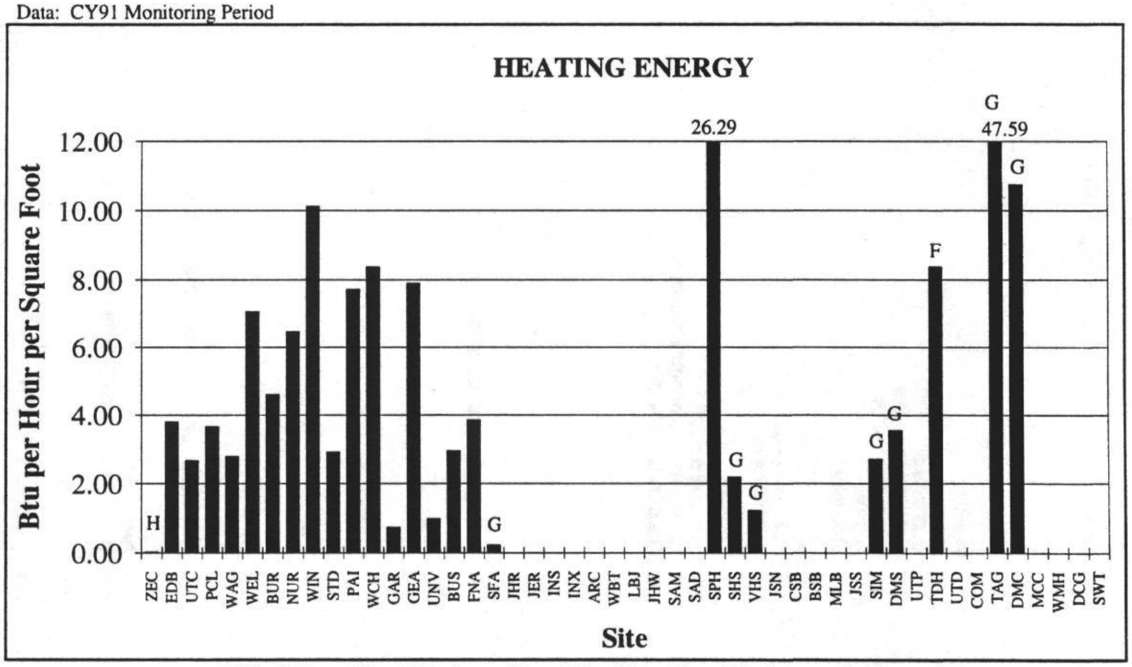
Data: CY91 Monitoring Period



Data: CY91 Monitoring Period



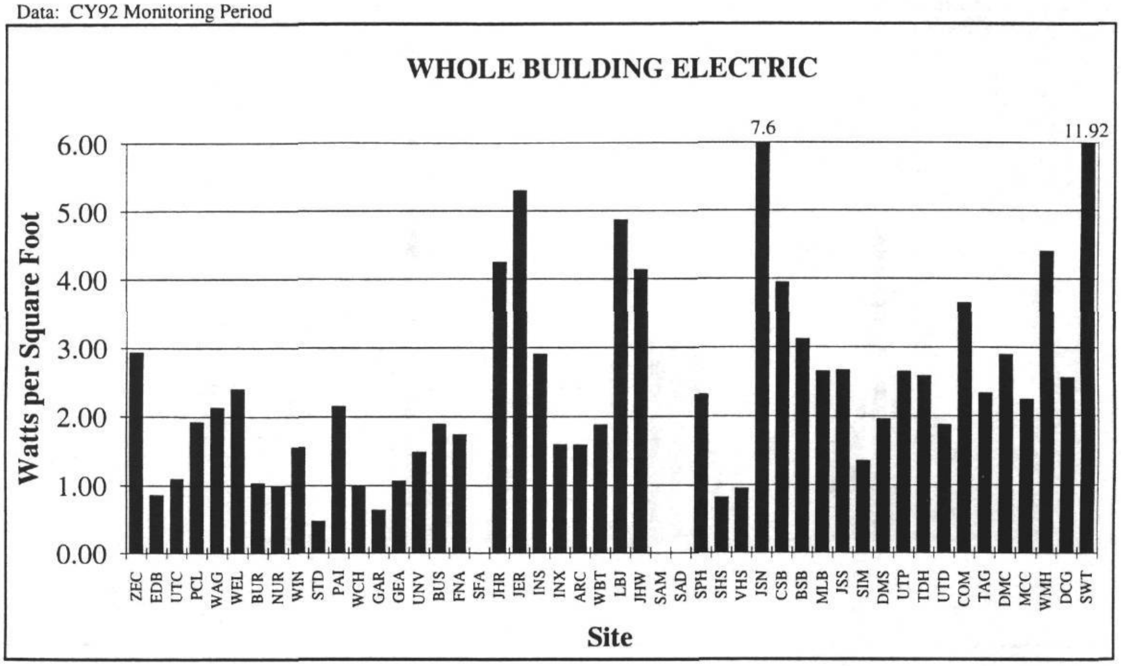
Data: CY91 Monitoring Period



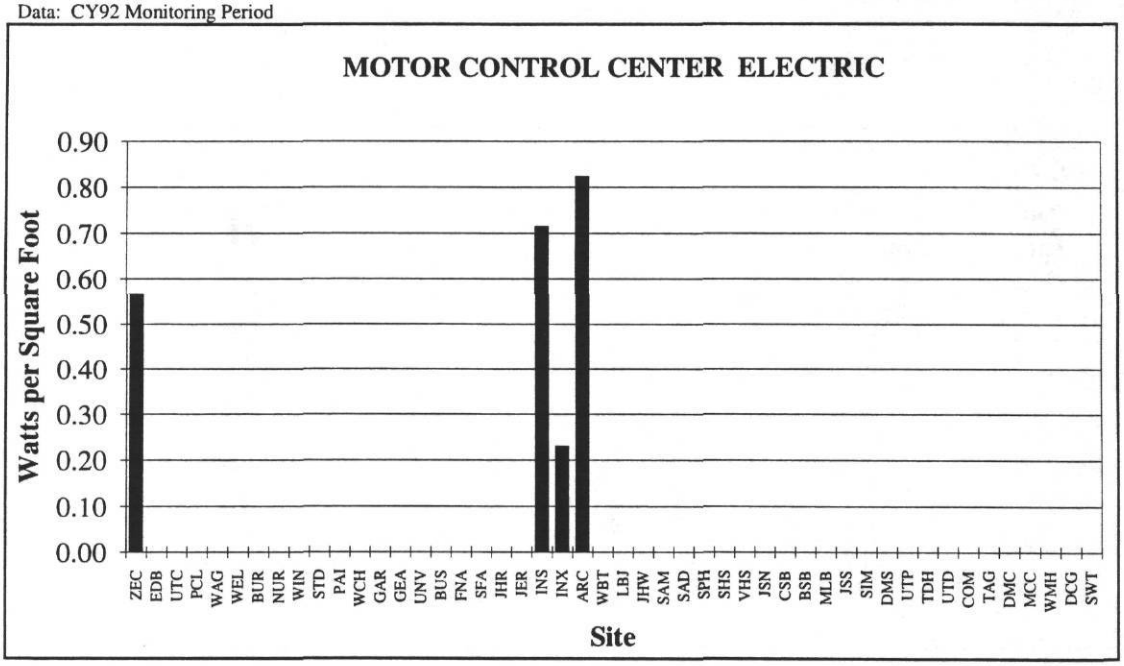
KEY: G-Natural Gas. F-Feedwater Flow. H-Hot Water Flow. All others are Condensate Flow

Calendar Year 1992 Monitoring Period Data Plots

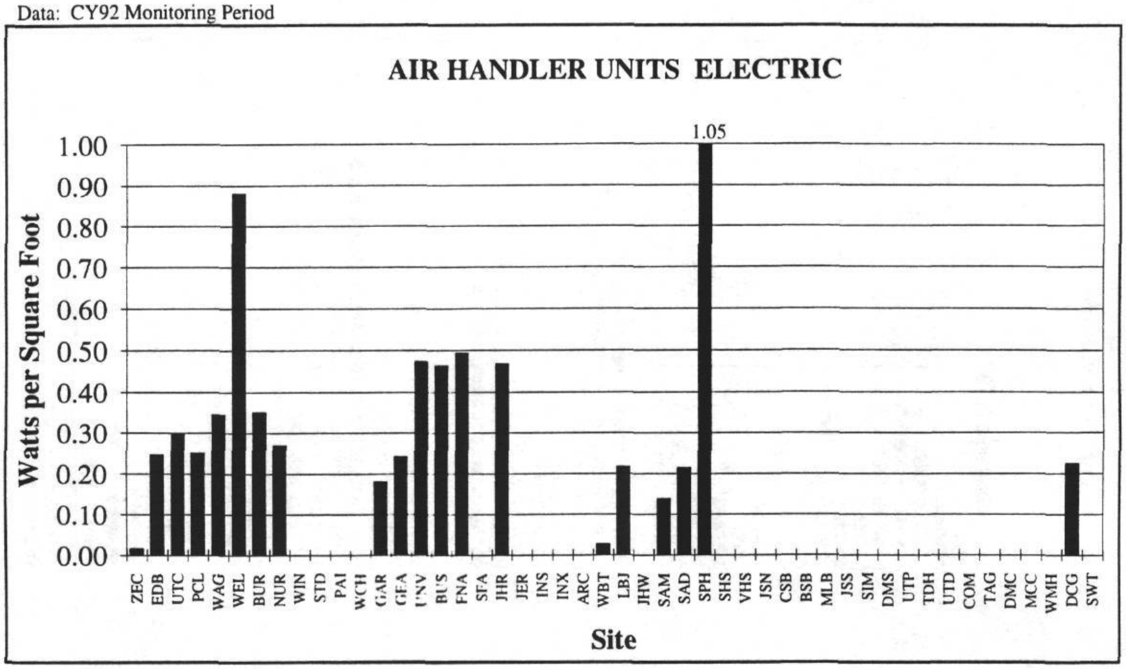
Data: CY92 Monitoring Period



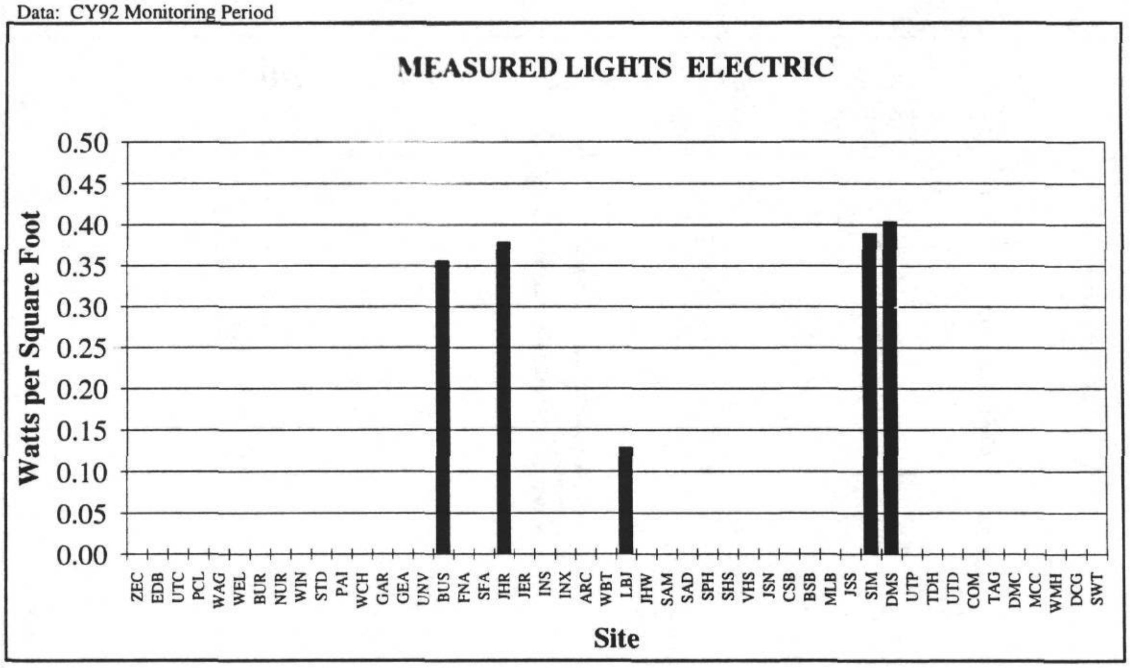
Data: CY92 Monitoring Period



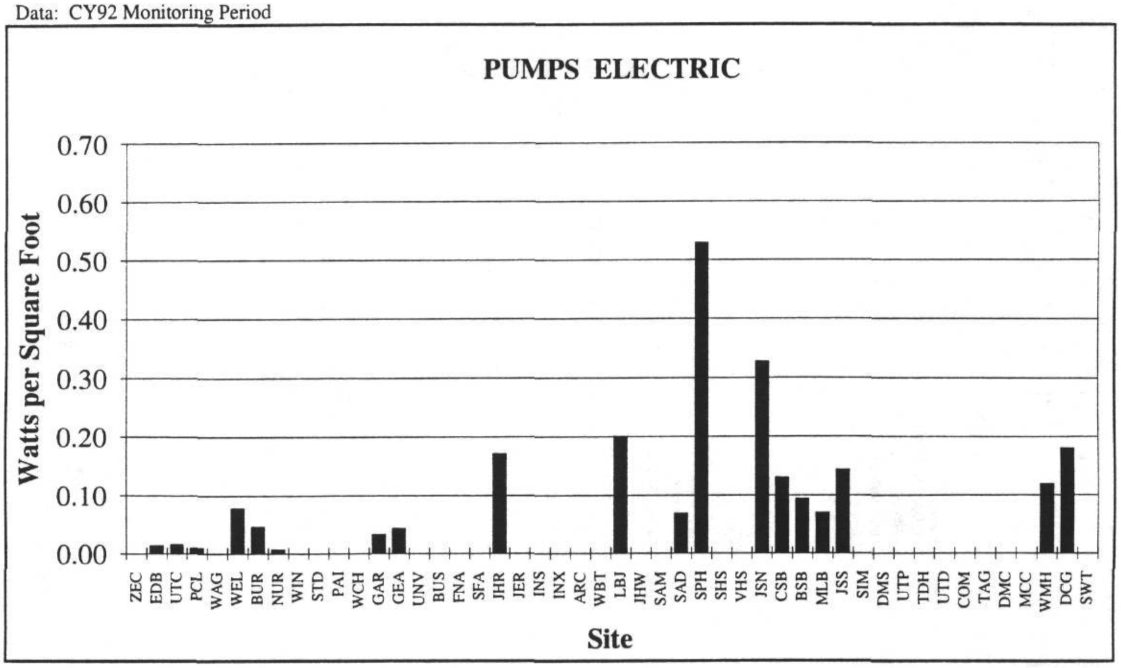
Data: CY92 Monitoring Period



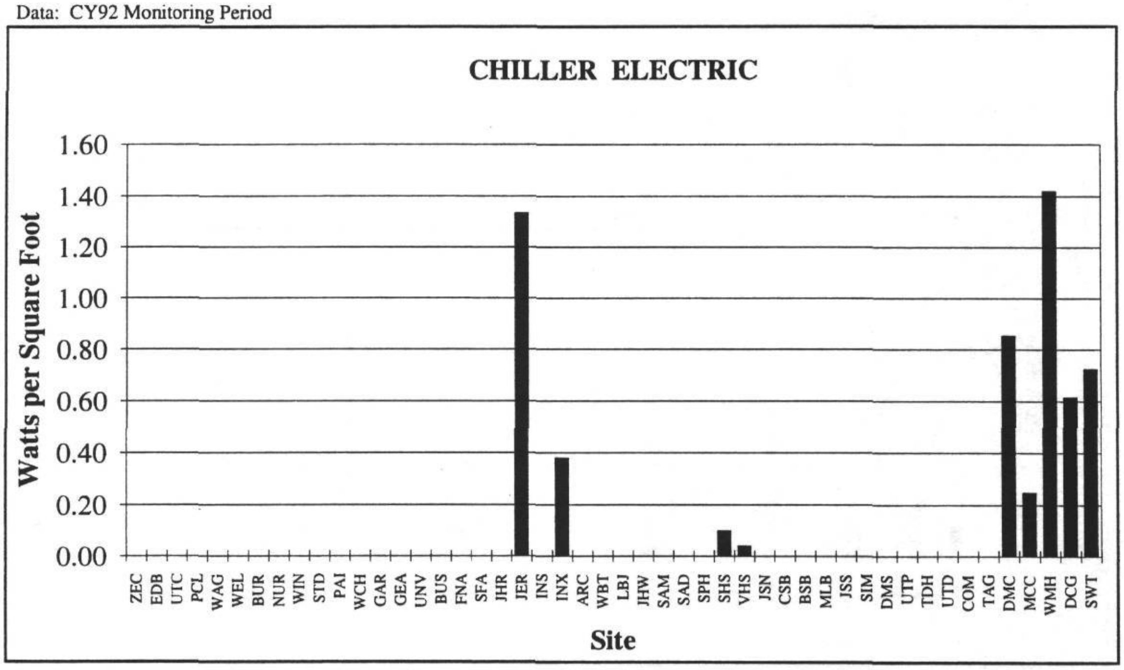
Data: CY92 Monitoring Period



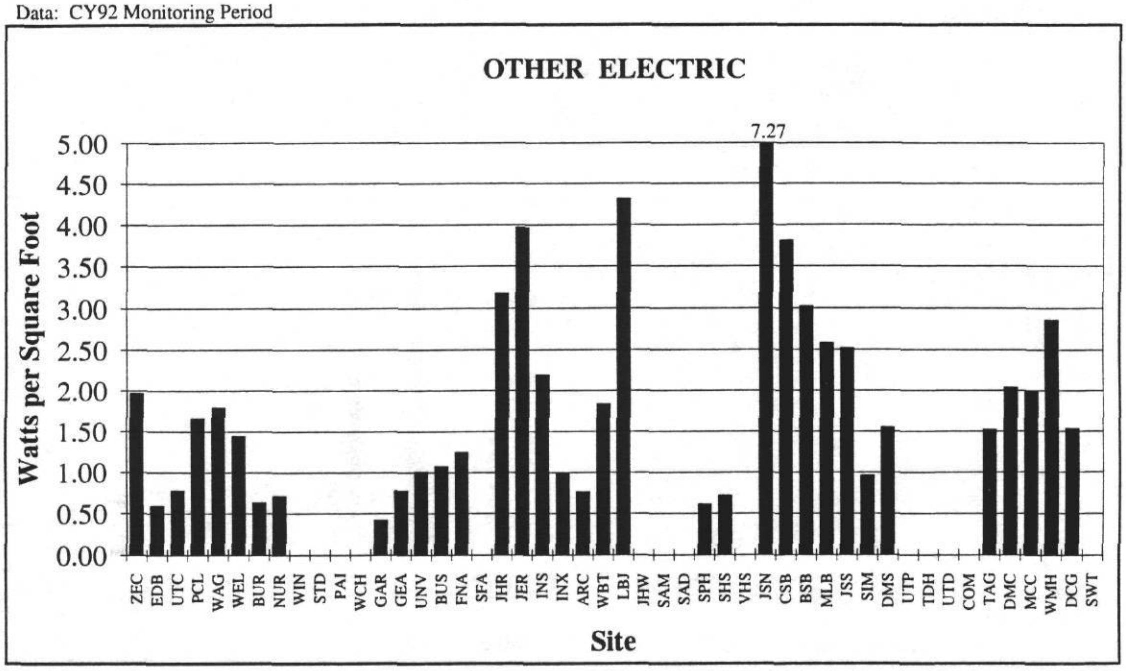
Data: CY92 Monitoring Period



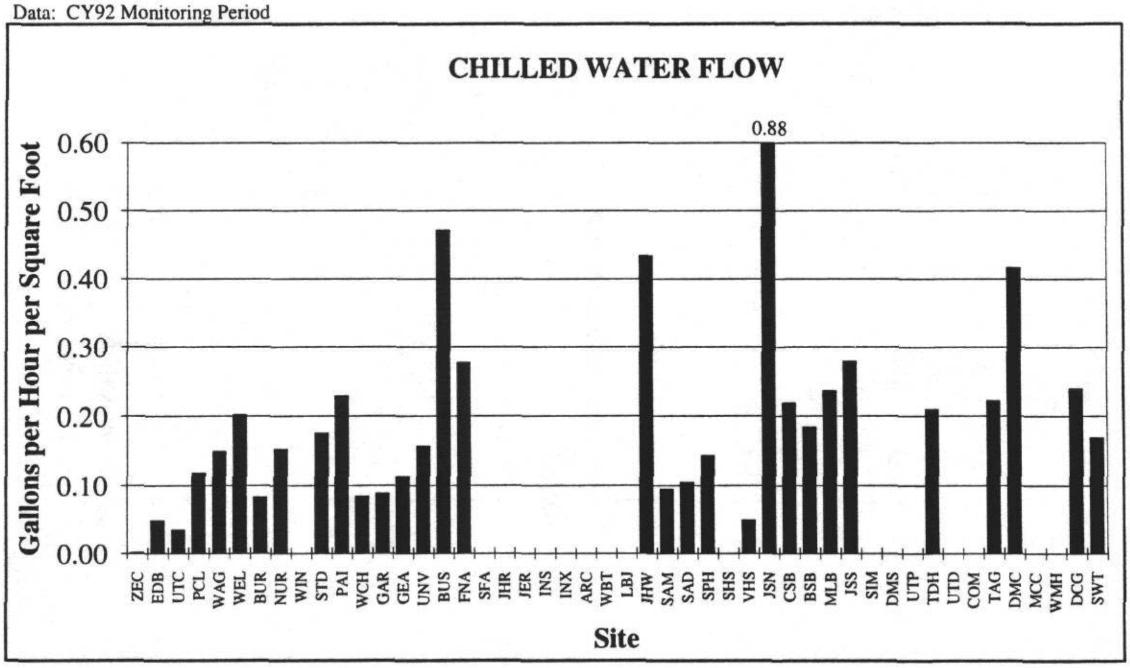
Data: CY92 Monitoring Period



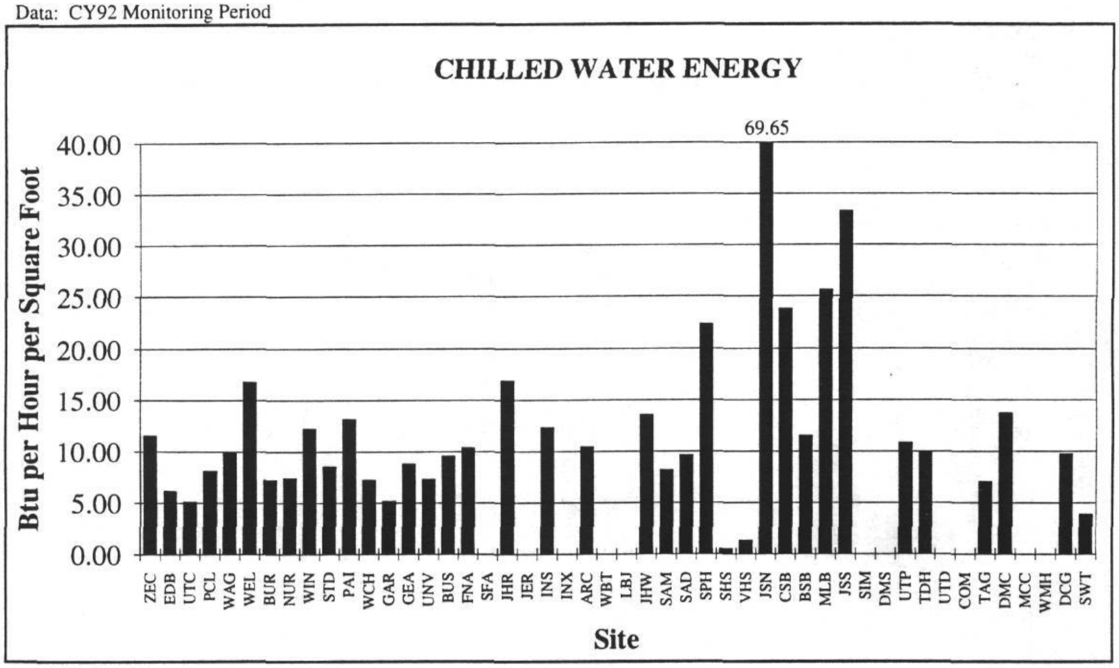
Data: CY92 Monitoring Period



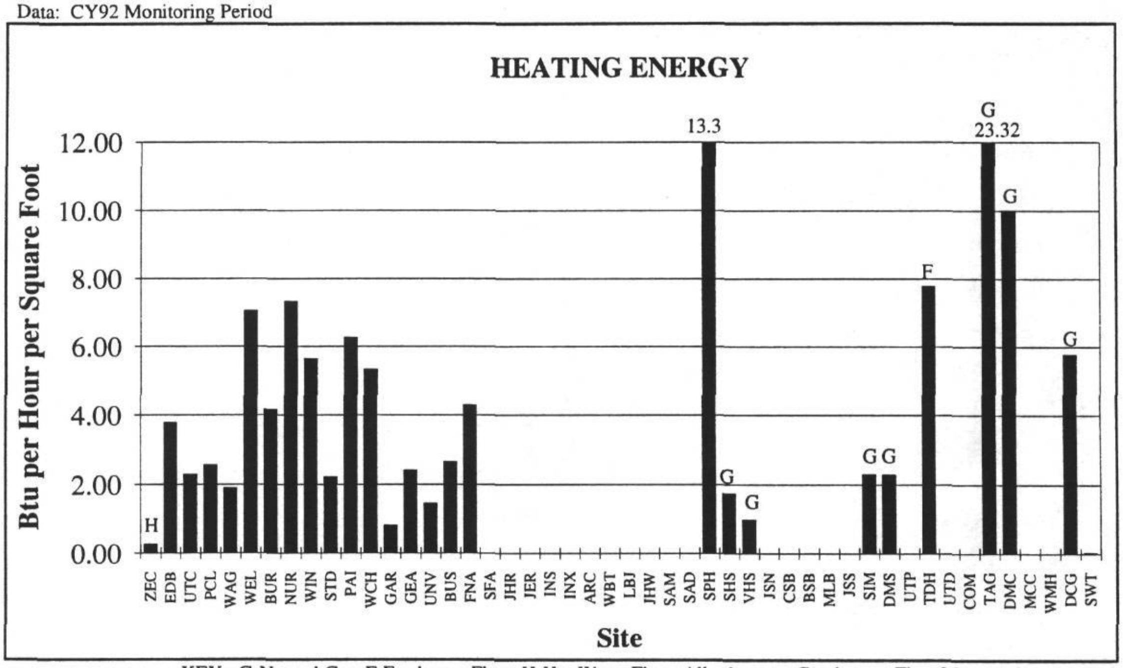
Data: CY92 Monitoring Period



Data: CY92 Monitoring Period



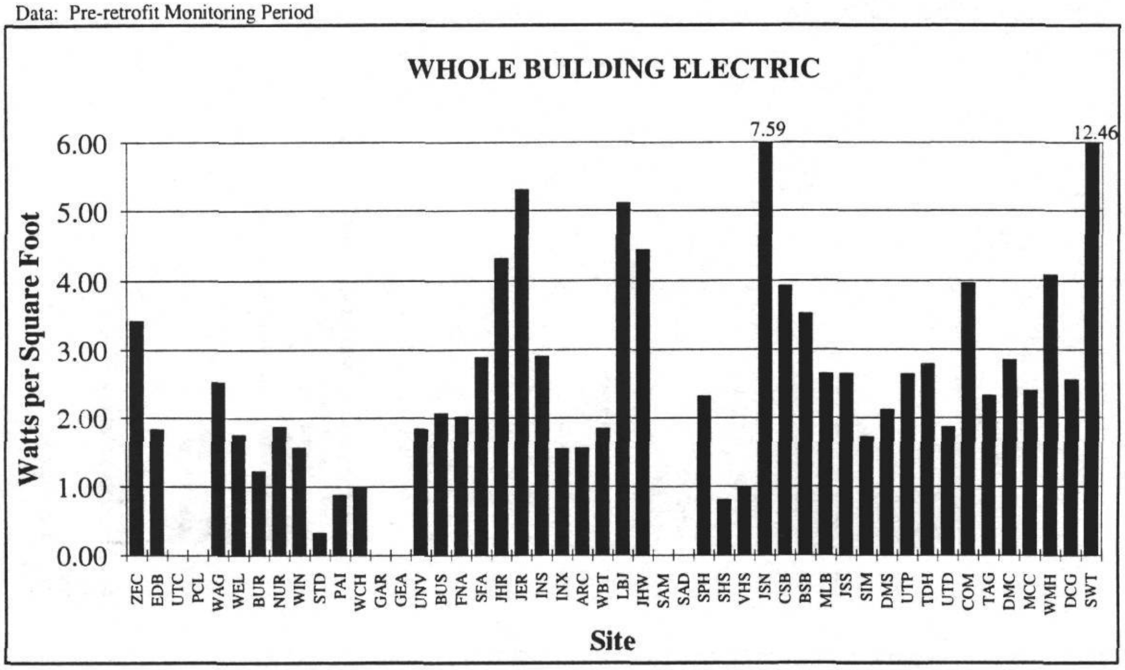
Data: CY92 Monitoring Period



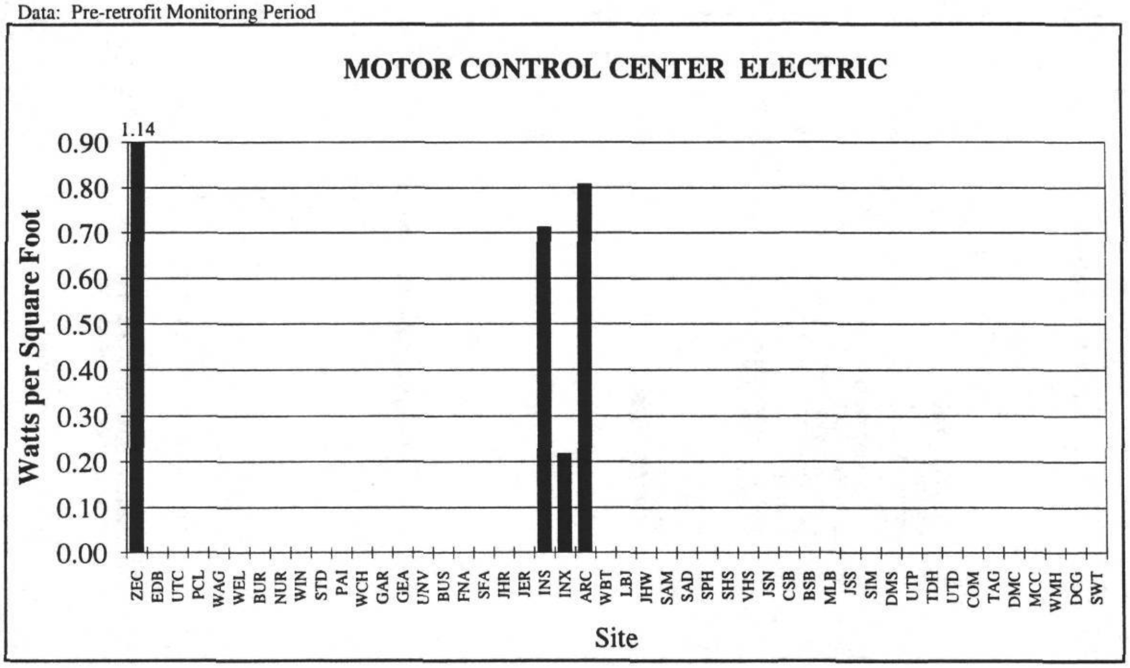
KEY: G-Natural Gas, F-Feedwater Flow, H-Hot Water Flow, All others are Condensate Flow Measured

Pre-Retrofit Monitoring Period Data Plots

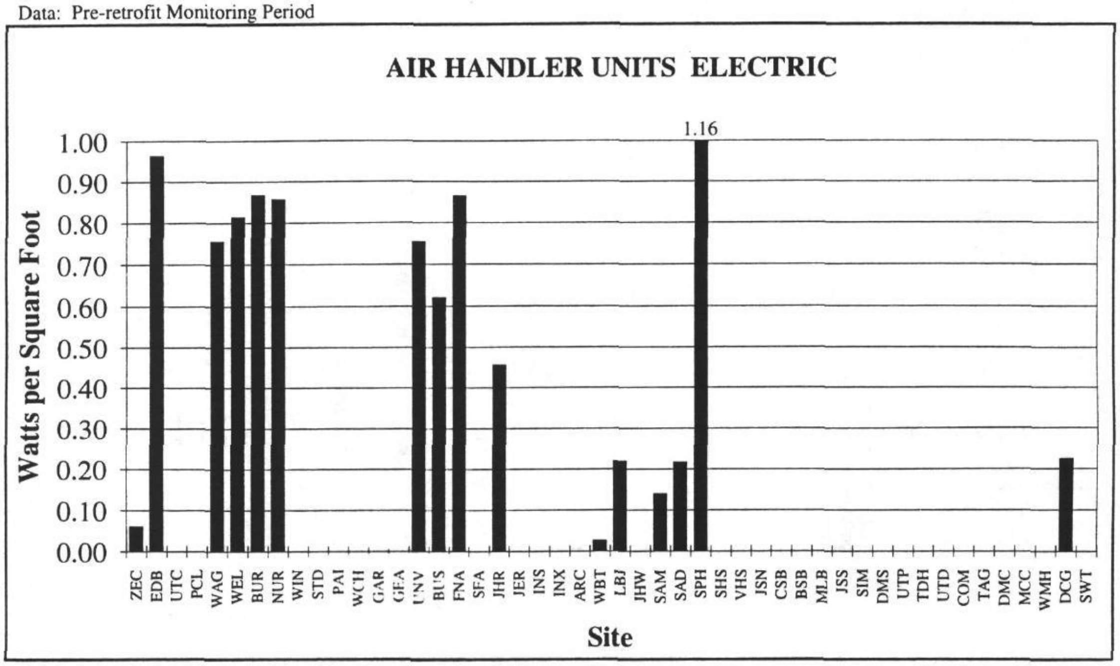
Data: Pre-retrofit Monitoring Period



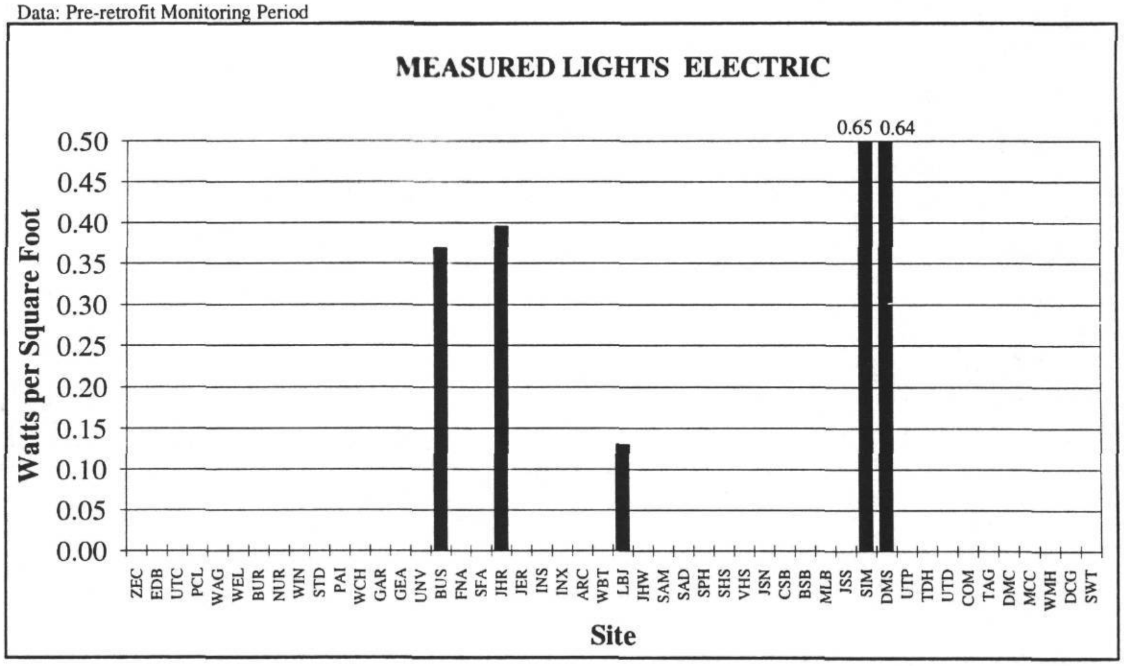
Data: Pre-retrofit Monitoring Period



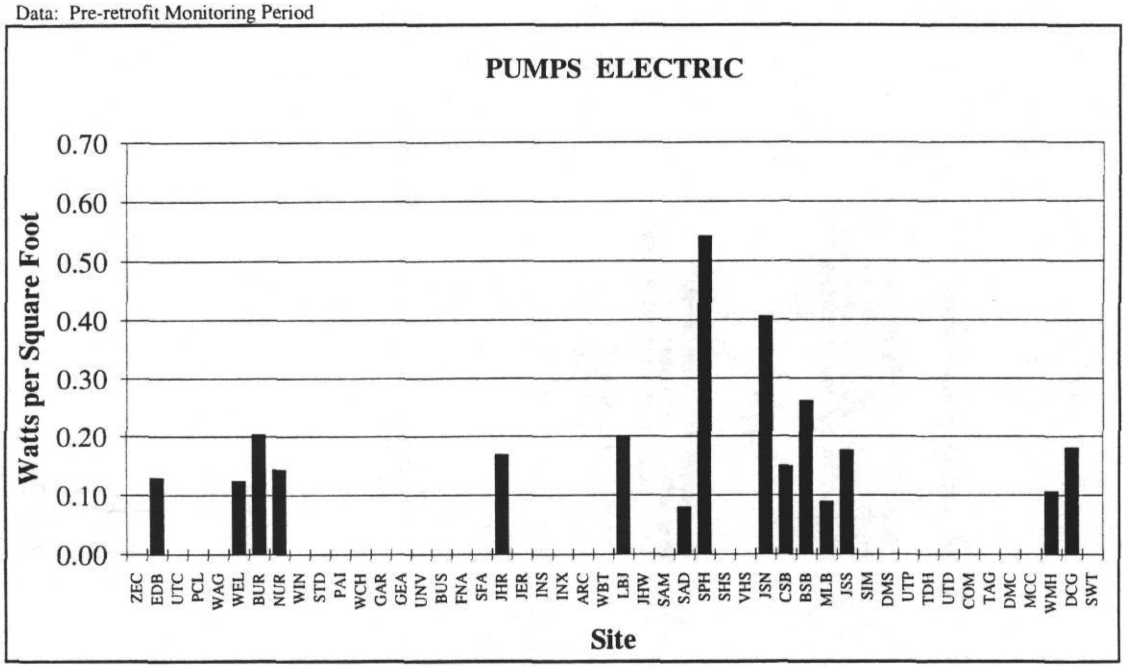
Data: Pre-retrofit Monitoring Period



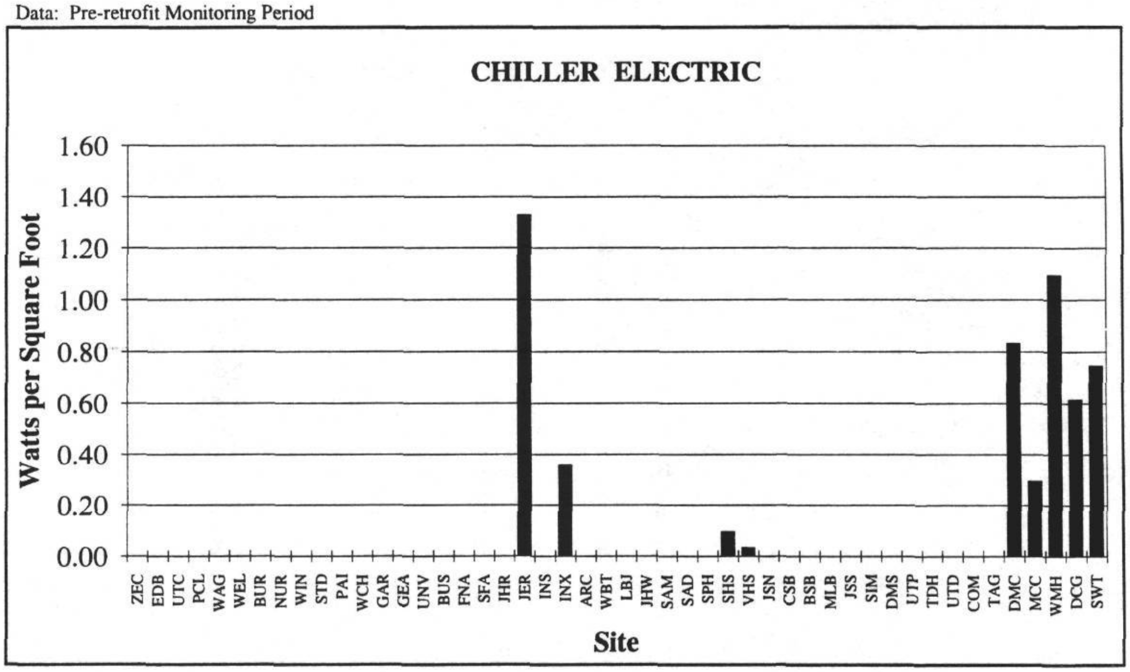
Data: Pre-retrofit Monitoring Period



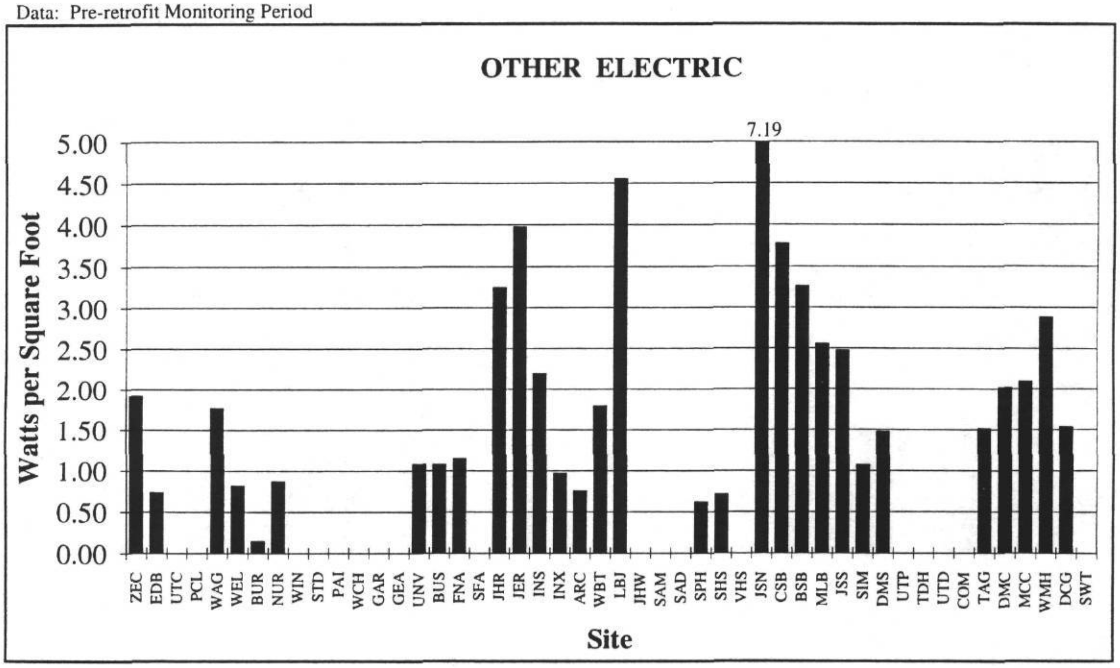
Data: Pre-retrofit Monitoring Period



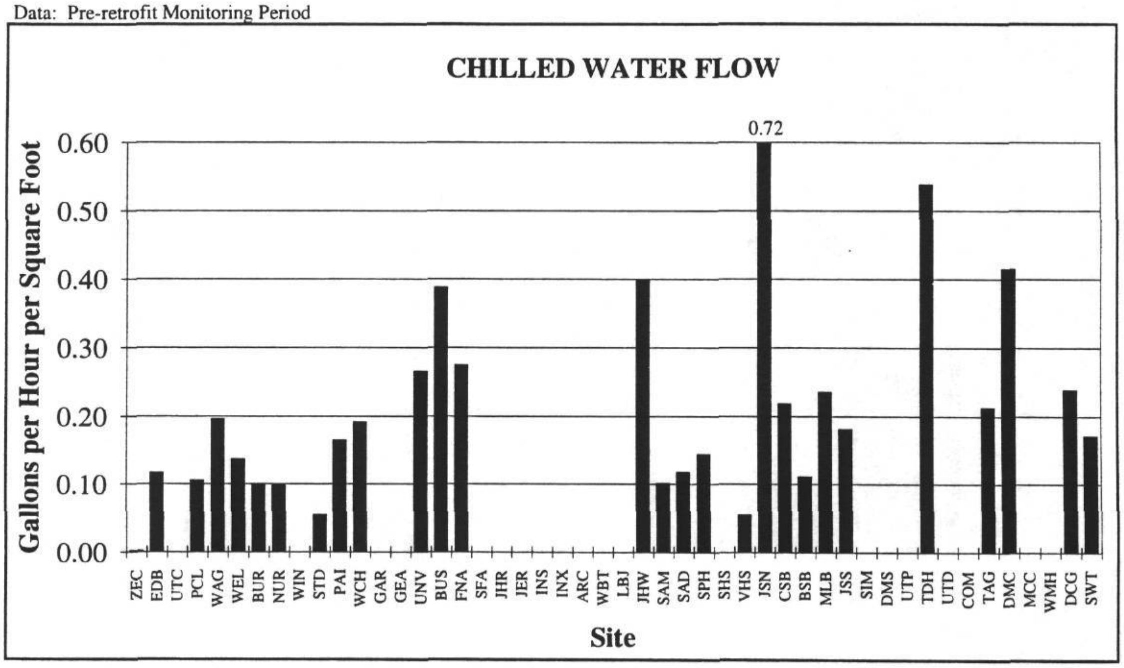
Data: Pre-retrofit Monitoring Period



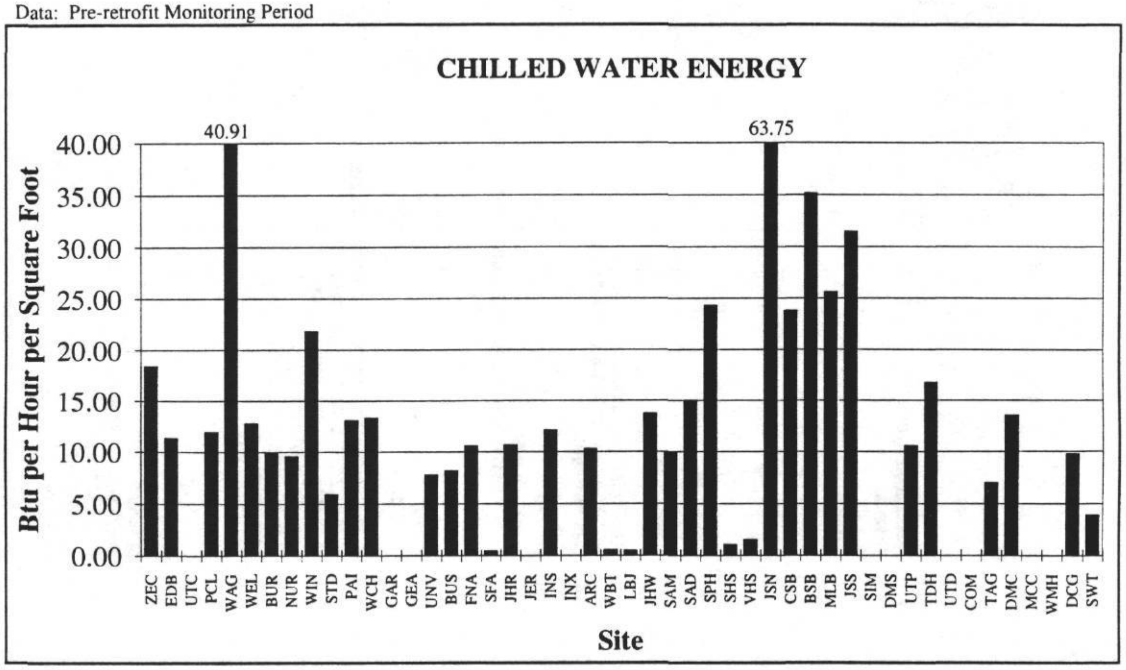
Data: Pre-retrofit Monitoring Period



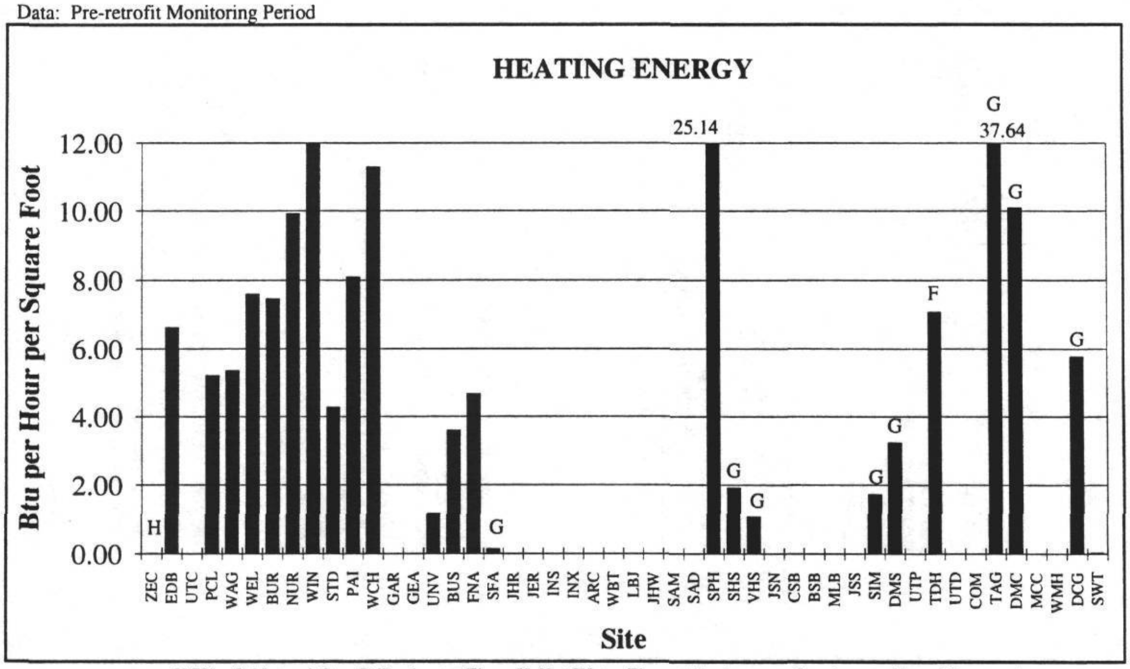
Data: Pre-retrofit Monitoring Period



Data: Pre-retrofit Monitoring Period



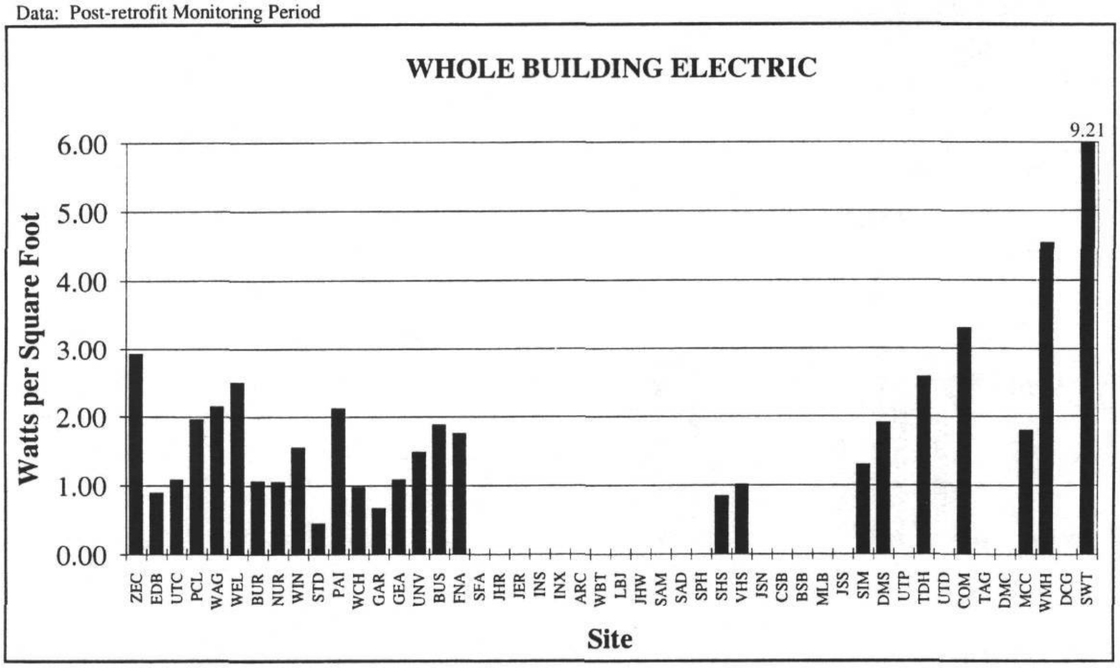
Data: Pre-retrofit Monitoring Period



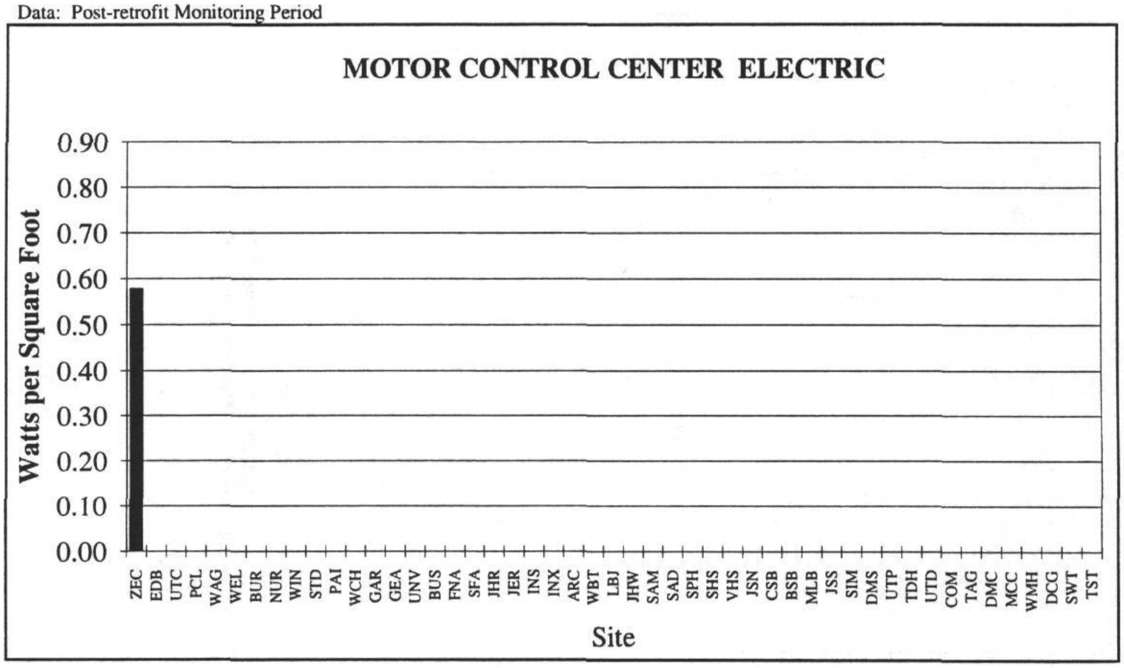
KEY: G-Natural Gas, F-Feedwater Flow, H-Hot Water Flow, All others are Condensate Flow Measured

Post-Retrofit Monitoring Period Data Plots

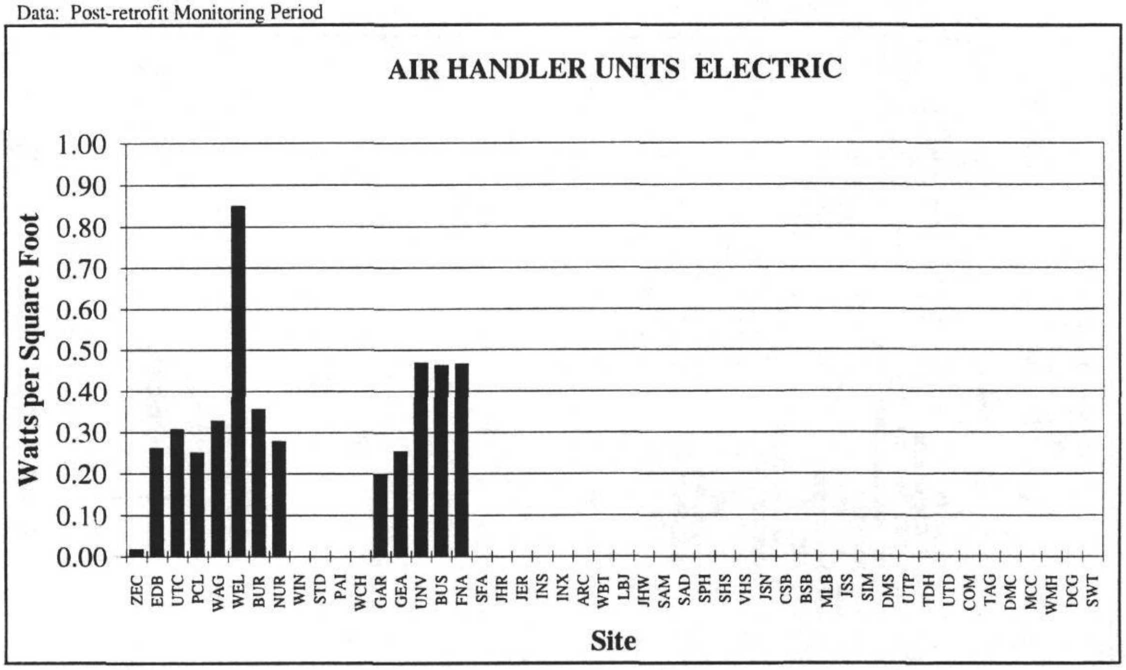
Data: Post-retrofit Monitoring Period



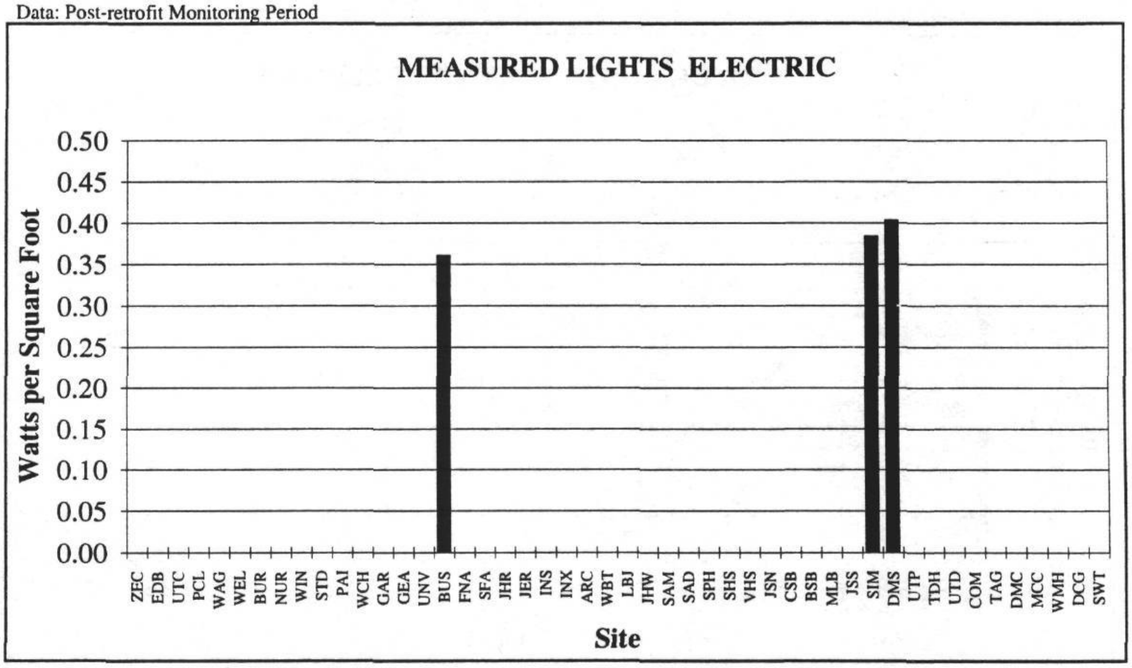
Data: Post-retrofit Monitoring Period



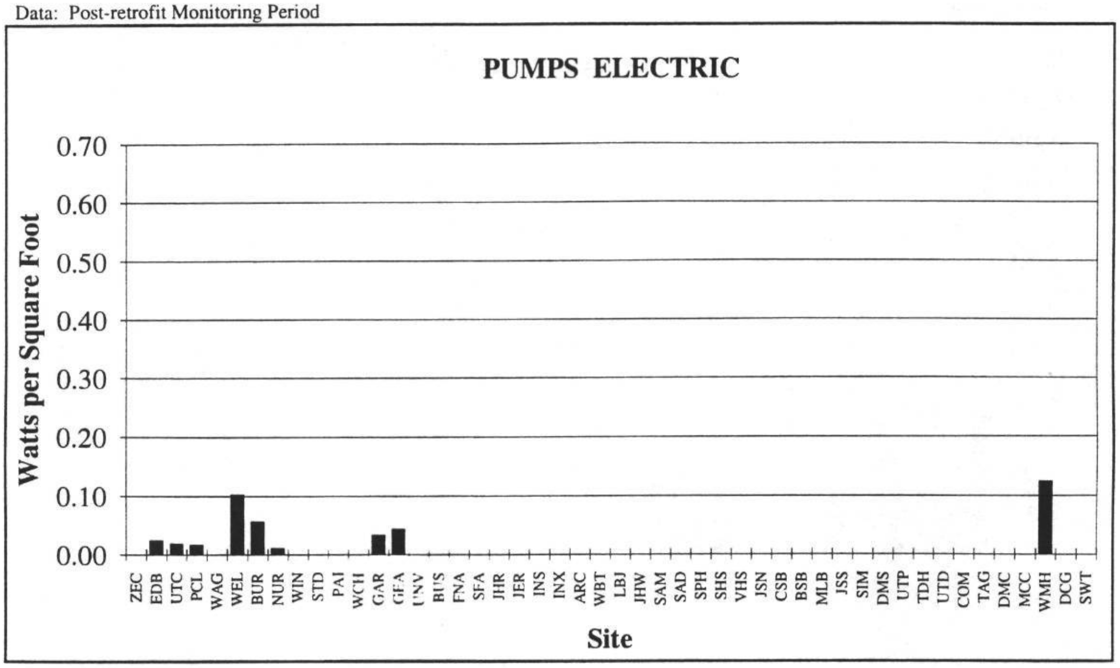
Data: Post-retrofit Monitoring Period



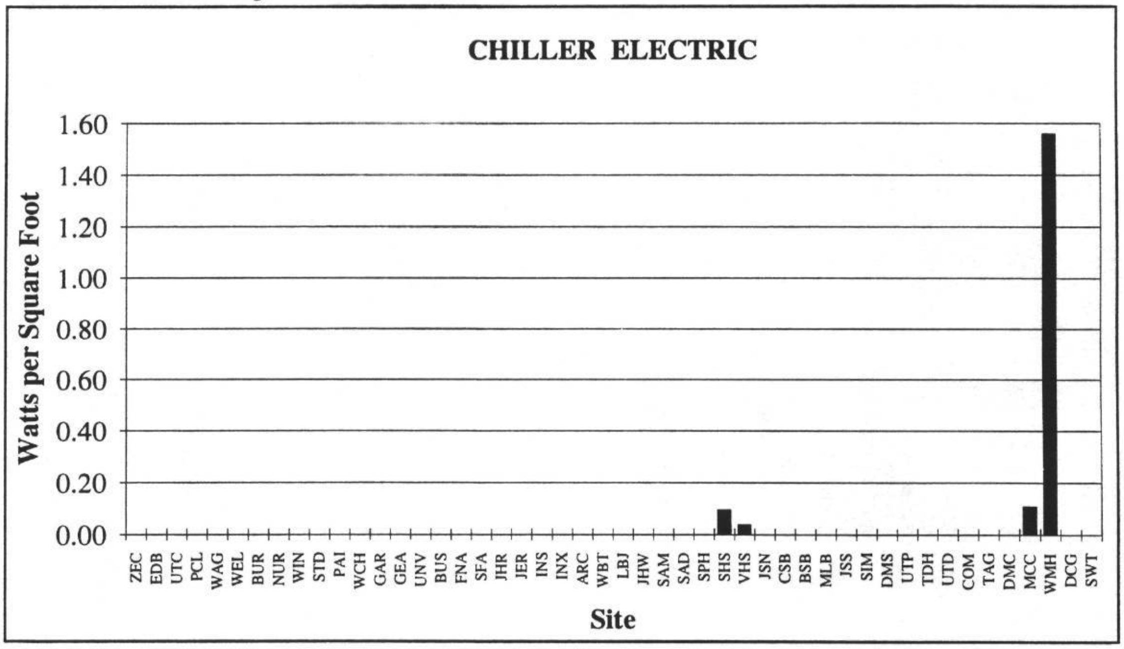
Data: Post-retrofit Monitoring Period



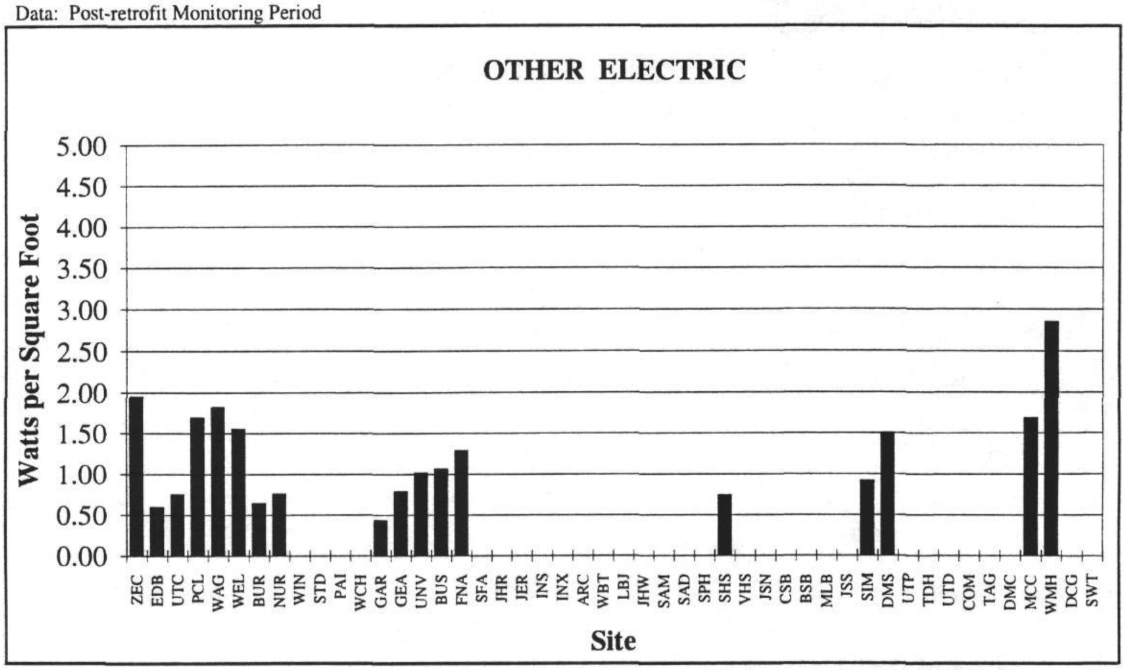
Data: Post-retrofit Monitoring Period



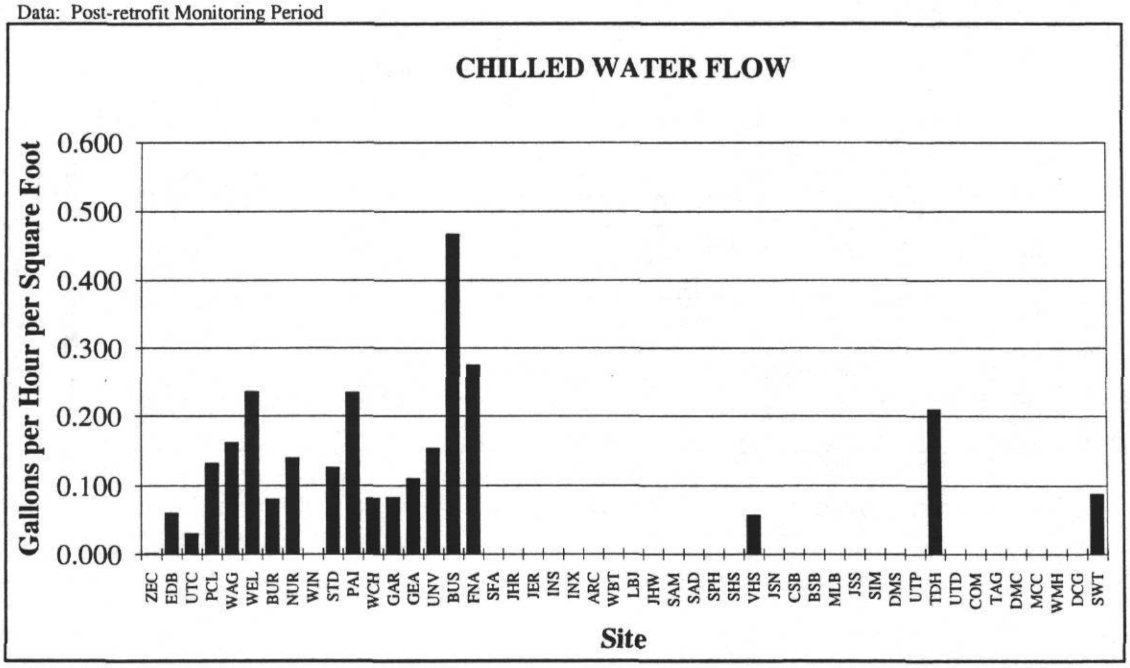
Data: Post-retrofit Monitoring Period



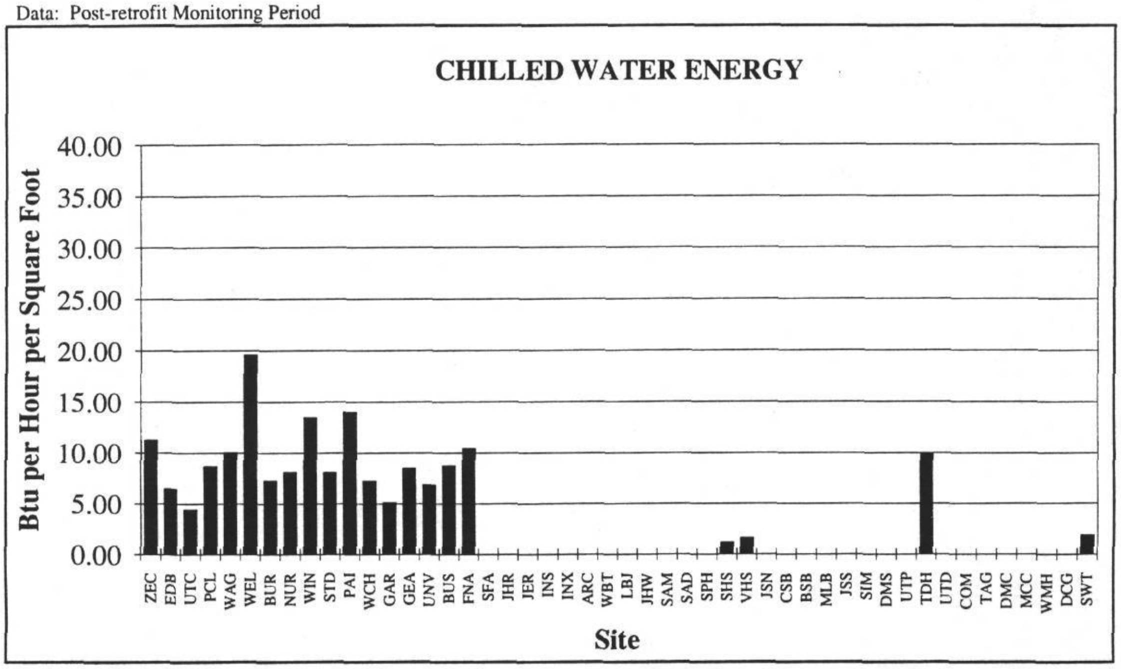
Data: Post-retrofit Monitoring Period



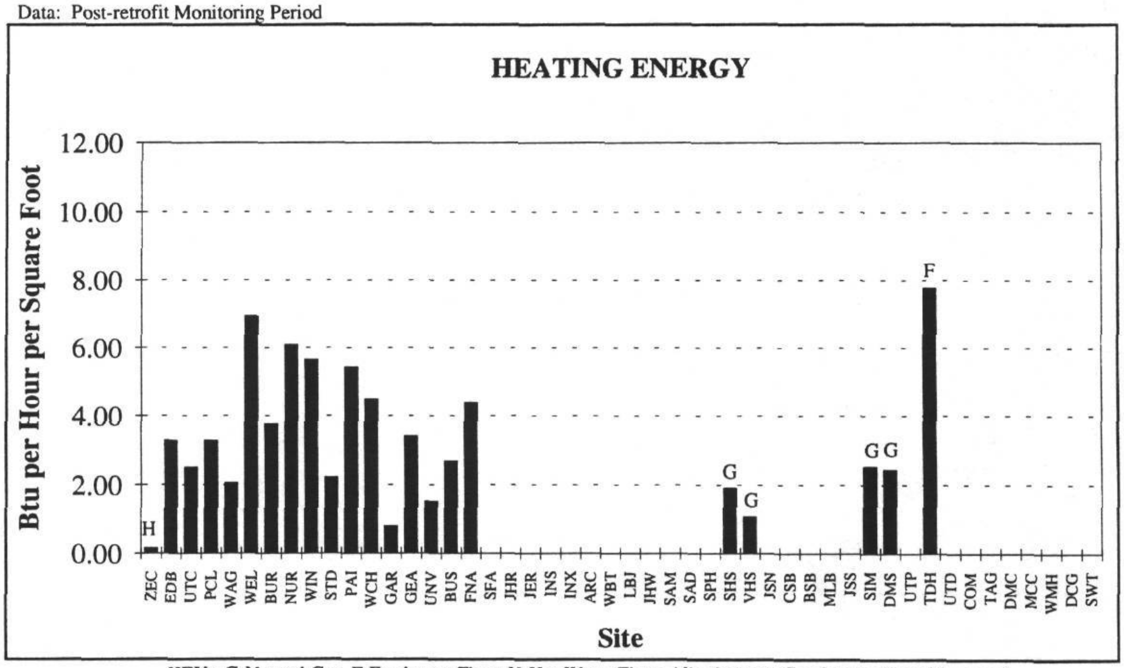
Data: Post-retrofit Monitoring Period



Data: Post-retrofit Monitoring Period



Data: Post-retrofit Monitoring Period



KEY: G-Natural Gas, F-Feedwater Flow, H-Hot Water Flow, All others are Condensate Flow Measured