Energy Use and Costs in Texas Schools and Hospitals

by

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Abstract

Procedures are presented for documenting and graphically presenting the monthly and annual energy use and costs for schools and hospitals. Collected data include monthly electrical energy consumed, monthly total electrical cost, monthly electrical demand charges, monthly natural gas consumed, monthly total natural gas costs, and total facility conditioned area. From this data, the monthly and annual energy use and cost performance of the facility is presented with the calculation of 10 use and cost indices including electrical- gas use/area, electrical - gas cost/area, electrical - gas unit cost, demand cost/area, and total energy use-cost/area. The results are presented both on tables and bar charts showing the monthly values for each parameter. Data was collected and presented for energy use and cost for over 60 schools in four school districts and for 35 hospitals/health care facilities in the state. All of the performance parameters showed a wide variation of values of the various performance indices among the participating institutions. For participating elementary schools, the annual electrical energy use/area ranged from 5.52 to 16.84 kwh/ft^2, the gas use from 9,363 to 66,639 Btu/ft^2, the electrical cost/area from 0.29 to 0.98 \$/ft^2 the gas cost/area from 0.03 to 0.24 \$/ft^2, and the total energy cost/area from 0.37 to 1.12 \$/ft^2. For hospitals the annual electrical electrical energy use/area ranged from 11.67 to 61.89 kwh/ft^2, the gas use from 26,192 to 418,267 Btu/ft^2, the electrical cost/area from 0.58 to 2.98 \$/ft^2 the gas cost/area from 0.16 to 2.23 \$/ft^2, and the total energy cost/area from 0.82 to 3.86 \$/ft^2. As expected, both the magnitudes of the energy indices and the range of variation were greater for the hospitals than for the schools. However, the gas use and costs for the hospitals seemed to generally fall within a more narrow range with only a few widely varying values as in comparison to values for the electric use and costs which were more generally scattered. It is noted that the conditioned area of the hospitals varied by a factor of approximately 42 while for the schools the areas varied by a factor of 2.3. The unit electrical total cost for the hospitals varied from approximately 2.2 ¢/kwh to a maximum of approximately 9¢/kwh while the gas unit costs ranged from a minimum of approximately 2.5 \$/mcf to a maximum of 7.1 \$/mcf.

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Introduction

The standard first step in a typical facility energy performance study is to collect and document the energy use and cost history for the facility. This information is essential in determining the following as a part of a comprehensive Energy Management Program:

- **The energy use and cost performance of the facility,**
- **How the energy use and costs compare with other facilities of similar type, function, and construction,**
- **The potential for energy use and cost reductions,**
- **Documentation of results of actual energy conservation activities.**

While no one relishes additional record keeping, these data are critical to the success of and Energy Management Program and should typically require only a few minutes each month to collect and enter the necessary information. Energy use and cost data for at lease one year and preferably for 3 to 4 years should be collected to provide performance data for a complete heating and cooling season(s). These data can also be used to identify problems associated with energy system operation or perhaps even errors in energy use or cost billing from your energy supplier.

The energy use and cost documentation and presentation procedures and results shown in this presentation were used in two energy use studies funded by the State of Texas. The first was funded by the Texas Building Energy Institute (TBEI) as a "**Pilot Project for the Development of a Public School System Energy and Resource End-Use Data base.**" The second was funded by the State Energy Conservation Commission (SECO) as part of a "**Program to Reduce Energy Use and Cost for Rural Health Care Facilities.**" The latter program also included a series of Energy Management Seminars for Texas Hospitals given throughout the state and one day, energy use and system performance energy audits funded by SECO. Both programs were completed during 1997.

Documentation and Presentation of Energy Use and Costs

Tabulation of energy use and cost data begins with information readily found on the monthly statement from your utility provider. The information needed is

- **Monthly electrical energy consumed (kwh)**
- **Monthly total electrical cost ($)**
- **Monthly electrical demand charges ($)**
- **Monthly natural gas consumed (mcf)**
- **Monthly total natural gas costs ($)**
- **Total facility conditioned (heated and cooled) area (ft^2)**

If all of the above quantities are known individually for multiple building, it is usually best to tabulate the data separately for each building. The key item that is not a part of the utility statement is the building/facility conditioned area for which the energy use and costs have been obtained. This is defined as follows:

> **Conditioned Area (ft^2): The total area of heated and/or cooled space measured from outside wall to outside wall.**

If this is not known is can usually be obtained from "as built" plans for the facility. Areas not heated or cooled such as entry ways, mechanical rooms, elevator space, or storage areas should not be included. If the conditioned area is not known, the total area can be used as a substitute, however note that the values of the energy use and cost performance indices described in the following section will be lower than if the conditioned area were used. If total area is used, major unconditioned areas such as garages or basements should still be subtracted from the total.

Table I shows and example of a completed energy data form which summarizes the tabulation of monthly values for use in tracking energy use and costs. Note that this requires that only five values be recorded each month. The form is set up on a standard spreadsheet and annual totals are calculated automatically. The biggest task associated with this element will be in compiling the data for previous years for the first time, particularly if the data are from records 3 or 4 years old. However, these can usually be obtained from the customer service office of the supplying utility if they are not readily available from your business office.

Energy Use and Cost Performance Indices

While the basic energy use and cost values are important, energy use and cost performance indices provide the best values with which to evaluate the energy performance

Table I. Monthly Energy Use & Cost Data Summary

Facility Name: _____ Location: _____ Cond. Area 151,000 ft.^{2}

Year 1993	Electricity: KWH	KWH $	Demand $	Natural Gas: MCF	MCF $
Jan.	607,500	$26,058		2,658	$9,783
Feb.	516,000	$24,027		2,593	$9,398
Mar.	531,000	$24,084		1,986	$7,314
April	784,500	$37,284			
May	559,500	$25,314		1,425	$6,269
June	615,000	$27,263		1,370	$5,896
July	702,000	$30,084		1,084	$4,872
Aug.	630,000	$30,345		1,045	$4,770
Sept.	667,500	$32,735		1,251	$5,491
Oct.	586,500	$31,060		1,566	$6,765
Nov.	538,500	$29,179		2,610	$10,279
Dec.	553,500	$28,034		2,486	$8,832
Total	**7,291,500**	**$345,467**	**$0**	**20,074**	**$79,669**

1994	KWH	KWH $	Demand $	MCF	MCF $
Jan.	607,500	$29,425		2,522	$9,086
Feb.	514,500	$27,447		2,369	$8,844
Mar.	564,000	$28,716		2,437	$9,070
April	613,500	$31,116		1,904	$8,220
May	558,000	$28,612	$7,706	1,517	$6,424
June	706,500	$33,176	$8,622	1,537	$6,261
July	672,000	$31,656	$9,292	1,187	$5,177
Aug.	646,500	$30,612	$9,039	1,406	$6,016
Sept.	688,500	$21,842	$9,039	1,488	$6,313
Oct.	571,500	$28,266	$8,786	1,621	$6,961
Nov.	588,000	$28,692	$8,786		
Dec.	606,000	$27,828	$7,899	2,466	$10,213
Total	**7,336,500**	**$347,388**	**$69,169**	**20,454**	**$82,585**

Year 1995	Electricity: KWH	KWH $	Demand $	Natural Gas: MCF	MCF $
Jan.	588,000	$29,192	$8,152	2,596	$10,280
Feb.	546,000	$27,232	$7,645	2,226	$8,545
Mar.	549,000	$28,137	$8,025	1,795	$7,003
April	571,500	$28,924	$8,152	1,823	$7,515
May	658,500	$32,450	$9,166	1,648	$6,816
June	646,500	$32,601	$9,419	1,450	$6,021
July	727,500	$33,059	$9,292	1,379	$5,742
Aug.	670,500	$31,972	$9,546	1,356	$5,379
Sept.	672,000	$24,651	$9,546	1,243	$4,811
Oct.	643,500	$30,677	$9,166	1,896	$7,407
Nov.	597,000	$29,275	$9,039	2,431	$9,633
Dec.	603,000	$28,847	$8,659	2,640	$10,089
Total	**7,473,000**	**$357,017**	**$105,807**	**22,483**	**$89,241**

1996	KWH	KWH $	Demand $	MCF	MCF $
Jan.	645,000	$29,560	$8,405	3141	$11,060
Feb.	594,000	$23,065	$8,786	2526	$8,680
Mar.	582,000	$29,835	$9,639	2551	$9,258
April	639,000	$31,322	$9,640	2148	$7,527
May					
June					
July					
Aug.					
Sept.					
Oct.					
Nov.					
Dec.					
Total	**2,460,000**	**$113,782**	**$36,470**	**10,366**	**$36,525**

Questions: Call Dr. Jerry R. Dunn, Texas Tech Univ., Dept. of Mechanical Engineering, Lubbock, TX. 79409 (806) 742-0966; Fax: (806) 742-3540

Form Prepared by: _____ Phone: _____

Please Supply Data for an entire year if possible

of each facility, particularly when comparing with values from other similar facilities. These values are typically computed as an energy use per unit area or as a cost per unit area. Computed monthly indices should include the following:

- **Monthly electrical use/area (kwh/ft^2)**
- **Monthly electrical unit cost (¢/kwh)**
- **Monthly gas use/area (Btu/ft^2)**
- **Monthly gas unit cost ($/mcf)**
- **Monthly total electric and gas use/area (Btu/ft^2)**
- **Monthly total electric and gas cost/area ($/ft^2)**
- **Monthly demand cost/area ($/ft^2)**
- **Monthly electrical cost/area ($/ft^2)**
- **Monthly gas cost/area ($/ft^2)**
- **Monthly total cost/area ($/ft^2)**

A computer based spreadsheet can be set up to compute these indices based on data entered from Table I. An example is shown in the Figures 1 and 2. Each data file provides the tabulated monthly data and calculated indices for a specified calendar year and has two sheets in the spreadsheet. Sheet one has the basic data and the energy use and unit cost indices. Sheet two has the cost per unit area indices both by month and season. The bar graphs provide graphical representations of the monthly values and are developed automatically once the tabular values are entered. Entering the correct year in the upper left corner of sheet one (cell A6) will change to the correct year at all other locations on the graphs. Entering the area in the first row (Jan.) for the table will result in that area being used for all subsequent months. If a mid-year change in conditioned area occurs, entering the correct area for the appropriate month will provide the correct area for all subsequent months. Note that the contribution for demand charges are shown on sheet 2. The spreadsheet used for this presentation is Microsoft Excel ®, however any standard spreadsheet should be capable of providing a similar presentation.

Use of Energy Use and Cost Records

With the number of different energy use and cost parameters presented on the sheets discussed previously, there are many ways in which these data can be used. First, having energy records for several years, trends in energy use and cost can be evaluated. These data and trends would be the starting point for a comprehensive energy audit of your facility and would be particularly useful in evaluating the results of specific energy management activities such as switching to energy efficient lighting or installing an energy management control system. The data would also help justify consideration of additional energy conservation activities. Monthly variations in costs/area can be used to identify the costs associated with seasonal variations or start-up problems in equipment use. The

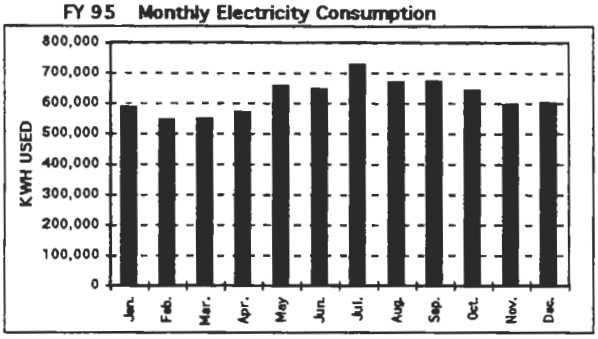
Fig. 1 Monthly Data Summary

2/10/98

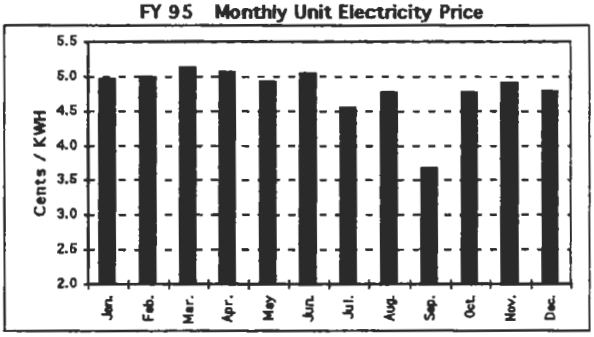
Facility Name:	Location:	Contact:
Electricity: All Meters	Natural Gas: All Meters	Phone:

FY 95	KWH	KWH $	MCF	MCF $	Cents / KWH	$ / MCF	KWH / Area KWH / ft²	MCF / Area Btu / ft²	Total Energy / Area Btu / ft²	Area ft²
Jan.	588,000	$29,192	2,596	$10,280	4.96	3.96	3.89	17,192	30,482	151,000
Feb.	546,000	$27,232	2,226	$8,545	4.99	3.84	3.62	14,742	27,083	151,000
Mar.	549,000	$28,137	1,795	$7,003	5.13	3.90	3.64	11,887	24,296	151,000
Apr.	571,500	$28,924	1,823	$7,515	5.06	4.12	3.78	12,073	24,990	151,000
May	658,500	$32,450	1,648	$6,816	4.93	4.14	4.36	10,914	25,798	151,000
Jun.	646,500	$32,601	1,450	$6,021	5.04	4.15	4.28	9,603	24,215	151,000
Jul.	727,500	$33,059	1,379	$5,742	4.54	4.16	4.82	9,132	25,576	151,000
Aug.	670,500	$31,972	1,356	$5,379	4.77	3.97	4.44	8,980	24,135	151,000
Sep.	672,000	$24,651	1,243	$4,811	3.67	3.87	4.45	8,232	23,421	151,000
Oct.	643,500	$30,677	1,896	$7,407	4.77	3.91	4.26	12,556	27,101	151,000
Nov.	597,000	$29,275	2,431	$9,633	4.90	3.96	3.95	16,099	29,593	151,000
Dec.	603,000	$28,847	2,640	$10,089	4.78	3.82	3.99	17,483	31,113	151,000
Annual Total	7,473,000	$357,017	22,483	$89,241	4.78	3.97	49.49	148,894	317,804	

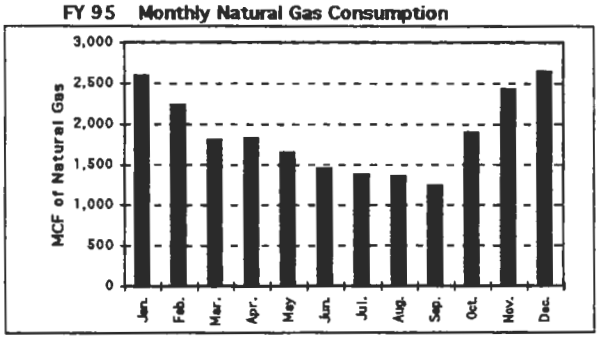
FY 95 Monthly Electricity Consumption



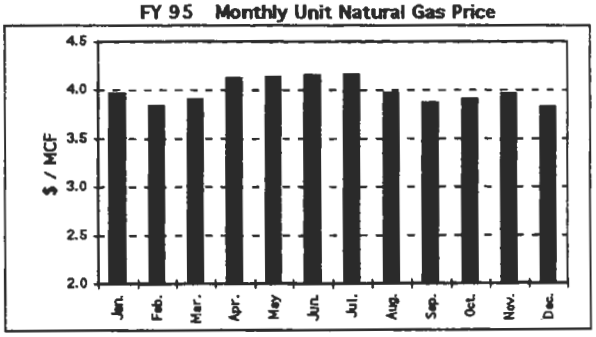
FY 95 Monthly Unit Electricity Price



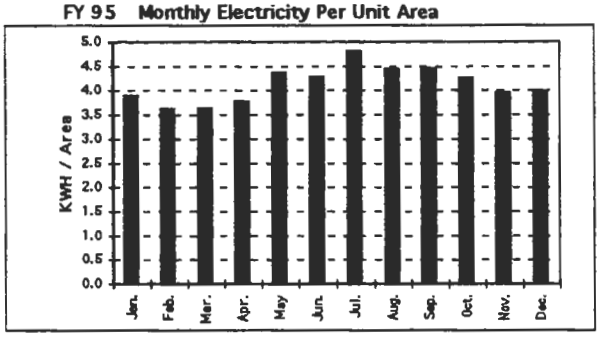
FY 95 Monthly Natural Gas Consumption



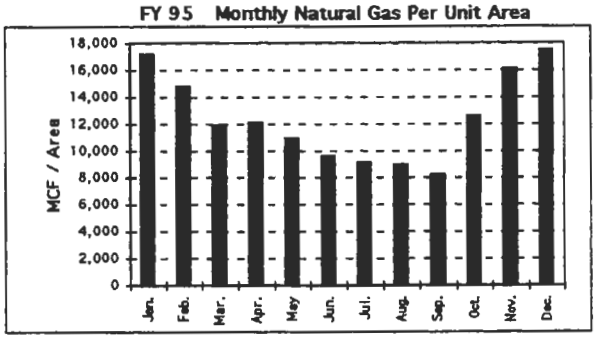
FY 95 Monthly Unit Natural Gas Price



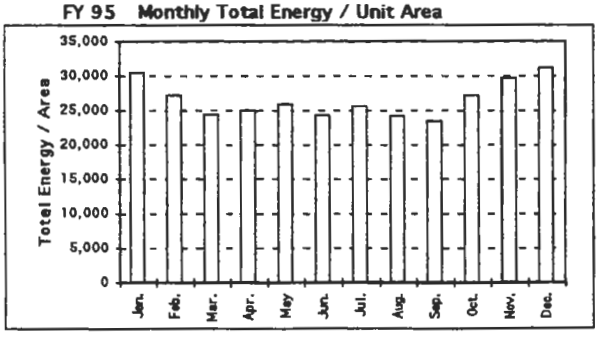
FY 95 Monthly Electricity Per Unit Area



FY 95 Monthly Natural Gas Per Unit Area



FY 95 Monthly Total Energy / Unit Area



FY 95 Seasonal Total Energy / Unit Area

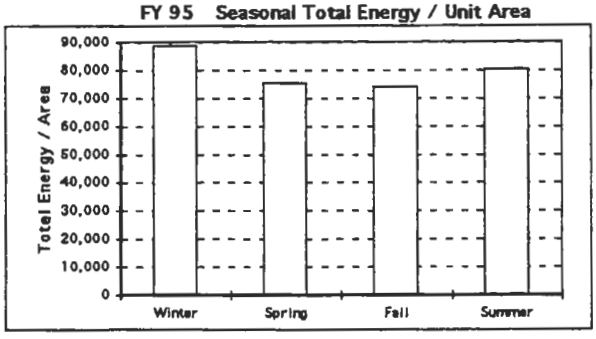


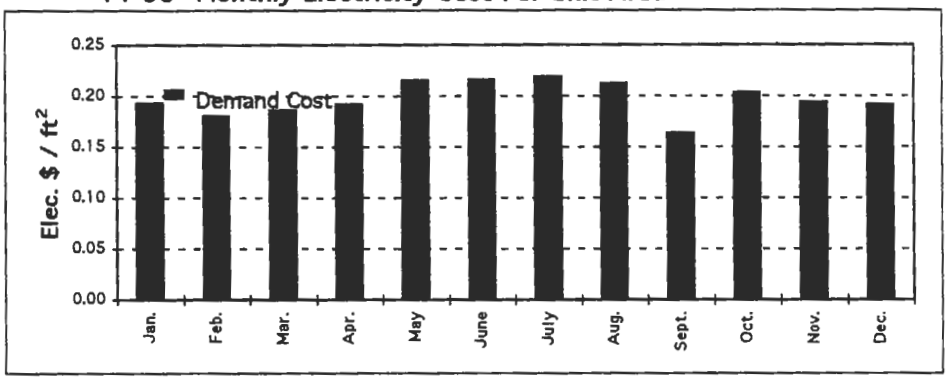
Fig. 2 Monthly Cost Summary

2/10/98

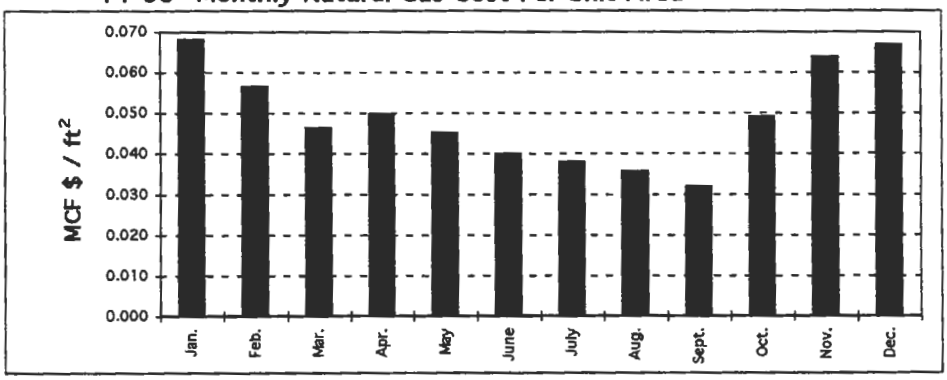
Facility Name: 0
Location: 0

FY 95	Demand Cost	Demand $ / ft^2	Electricity KWH $ / ft^2	Natural Gas MCF $ / ft^2	Total $ / ft^2
Jan.	$8,152	0.0540	0.19	0.068	0.26
Feb.	$7,645	0.0506	0.18	0.057	0.24
Mar.	$8,025	0.0531	0.19	0.046	0.23
Apr.	$8,152	0.0540	0.19	0.050	0.24
May	$9,166	0.0607	0.21	0.045	0.26
June	$9,419	0.0624	0.22	0.040	0.26
July	$9,292	0.0615	0.22	0.038	0.26
Aug.	$9,546	0.0632	0.21	0.036	0.25
Sept.	$9,546	0.0632	0.16	0.032	0.20
Oct.	$9,166	0.0607	0.20	0.049	0.25
Nov.	$9,039	0.0599	0.19	0.064	0.26
Dec.	$8,659	0.0573	0.19	0.067	0.26
Annual Total	$105,807	$0.70	$2.36	$0.59	$2.96

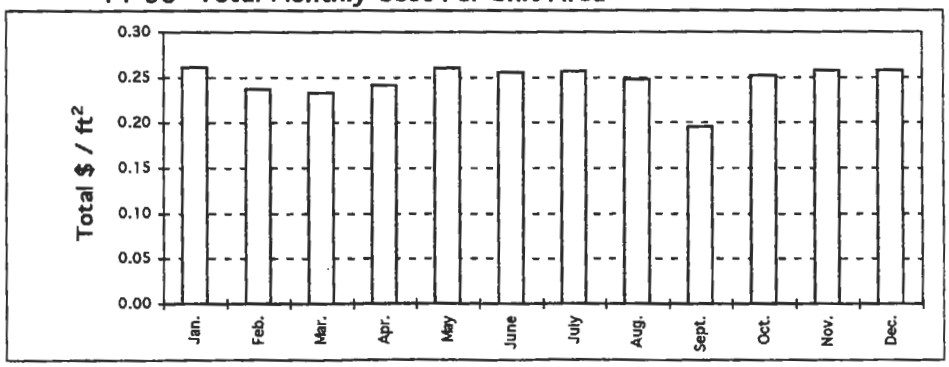
FY 95 Monthly Electricity Cost Per Unit Area



FY 95 Monthly Natural Gas Cost Per Unit Area



FY 95 Total Monthly Cost Per Unit Area



monthly graphs can also be helpful in identifying billing or utility metering problems. Monthly indicators that appear unusually high when compared to similar months may indicate billing problems or even operational problems with specific items of equipment.

Finally, these data can be used to compare with representative values from other similar facilities as an indication of the relative energy use and costs of your facility. However, care should be taken in using this type of comparison as variations in function, occupancy, climate, unit energy costs, and energy system configuration can lead to significant variations even for similar facilities such as schools or hospitals.

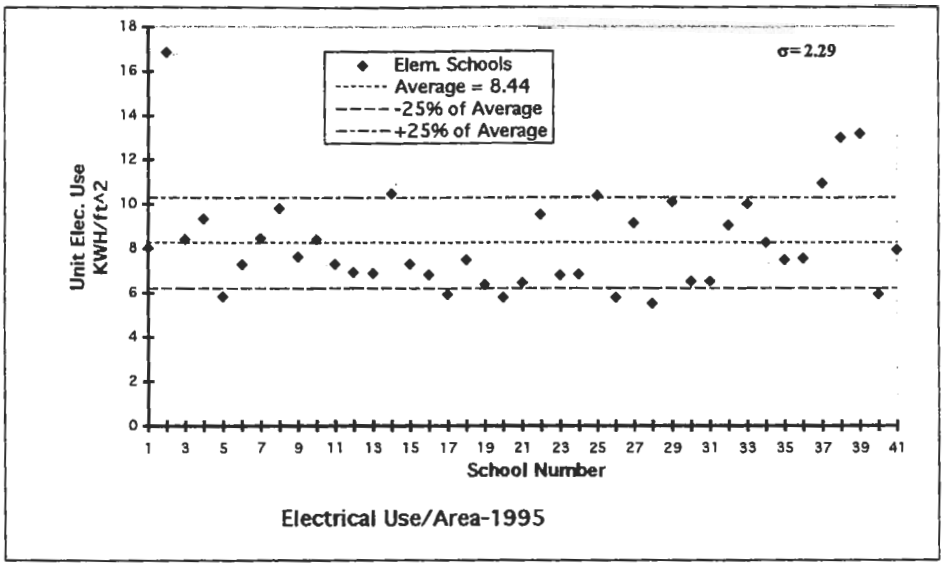
Energy Use and Costs for Public Schools

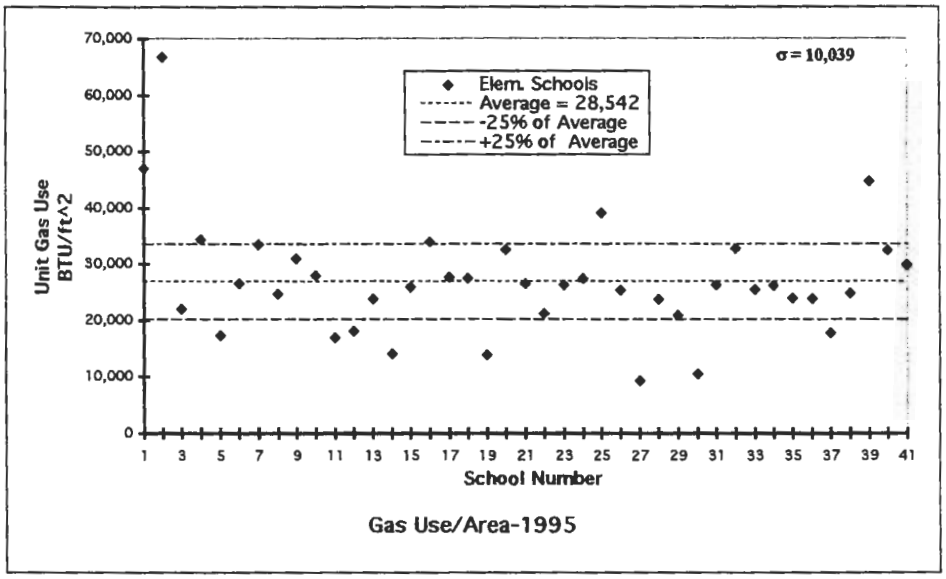
As stated previously, the procedures described in the previous sections were used to document the energy use and cost performance for a small number of Texas schools in a project funded by TBEI. Originally, data was to be obtained from six Texas school districts, three located in the Lubbock area and three located in the gulf coast region near Houston and Beaumont. However, once the project started, only four of the six responded to the follow-up request to provide data: Lubbock, New Deal, Roosevelt, and Katy Independent School Districts. The data provided by these schools included the following:

Data Collected

Lubbock ISD:	Electricity and Natural Gas, Use and Cost, 5 years
New Deal ISD:	Electricity, 4 years; Natural Gas, 2 years
Roosevelt ISD:	Electricity, 4 years; Natural Gas, 2 years
Katy ISD:	Electricity and Natural Gas, 1 year.

It is noted that the project director expects that a part of the source of the variability in the computed energy indices is due to a probable inconsistency in the school area figures provided for use by the project. In some cases the area was known and reported with reasonable accuracy by facility managers and in others we have just estimates. In some cases we have the area of conditioned space while in others, total structure area. In one case the area was obtained from a freehand sketch on a yellow 8 1/2" x 11" tablet provided by the maintenance person for the school. The compiled data were grouped by school level: Elementary, Middle, and Senior High schools, for evaluation purposes. In performing the statistical evaluation of the data, Middle and Senior High Schools were evaluated together because of the much smaller number of participating schools in these categories and because of the very similar uses of the two, i.e. both typically have significant sports activities as well as similar academic responsibilities. Figures 3 - 6 show results of the energy use and cost documentation and Tables II and III provide summaries of these results for the elementary and middle and senior high schools respectively.





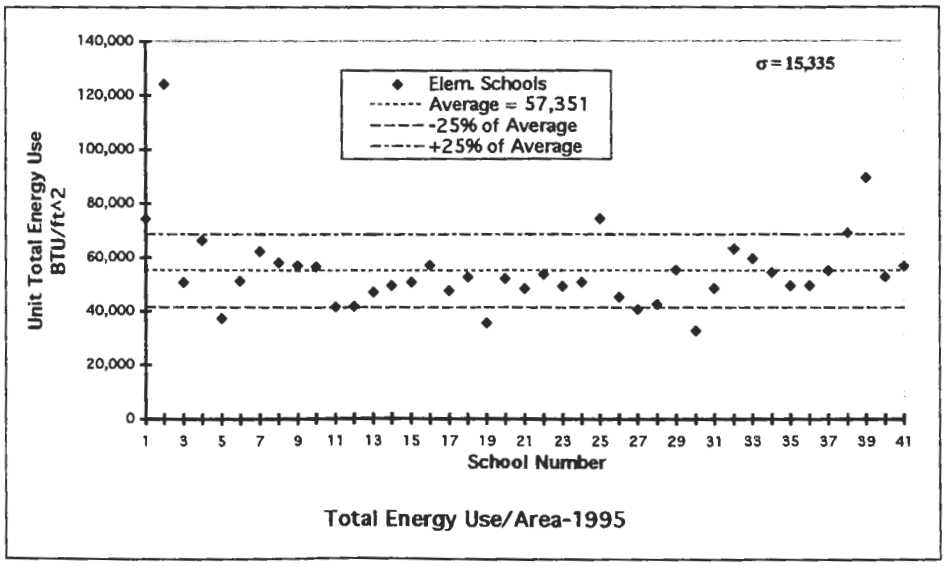
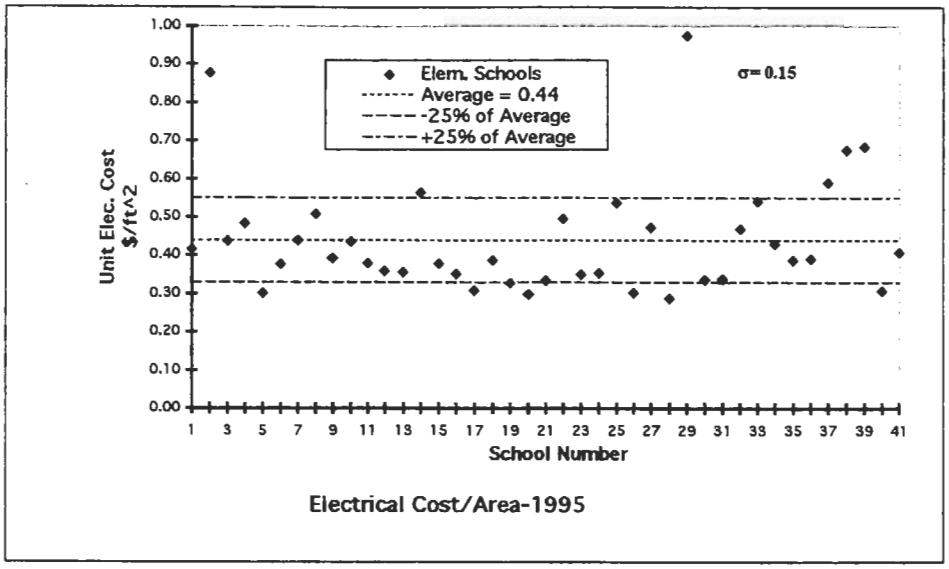
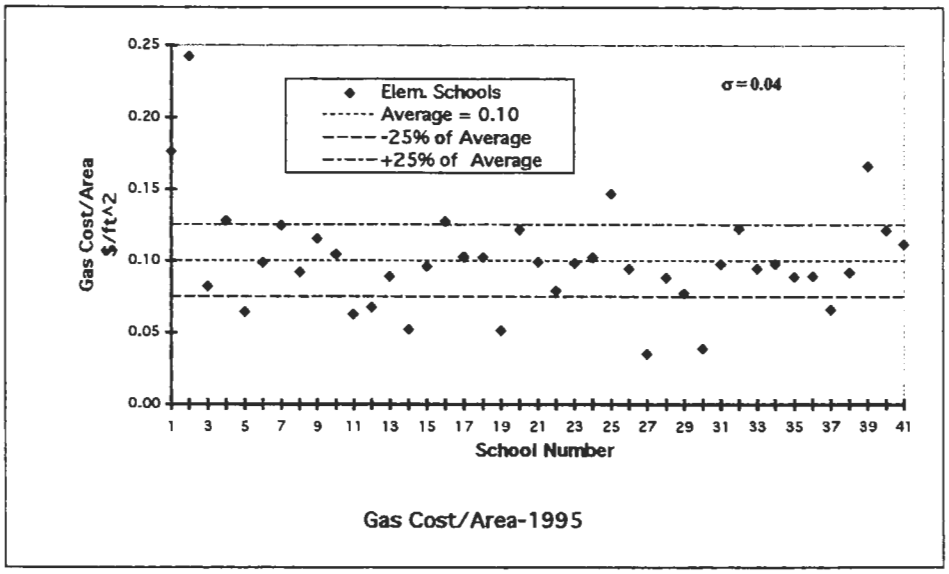


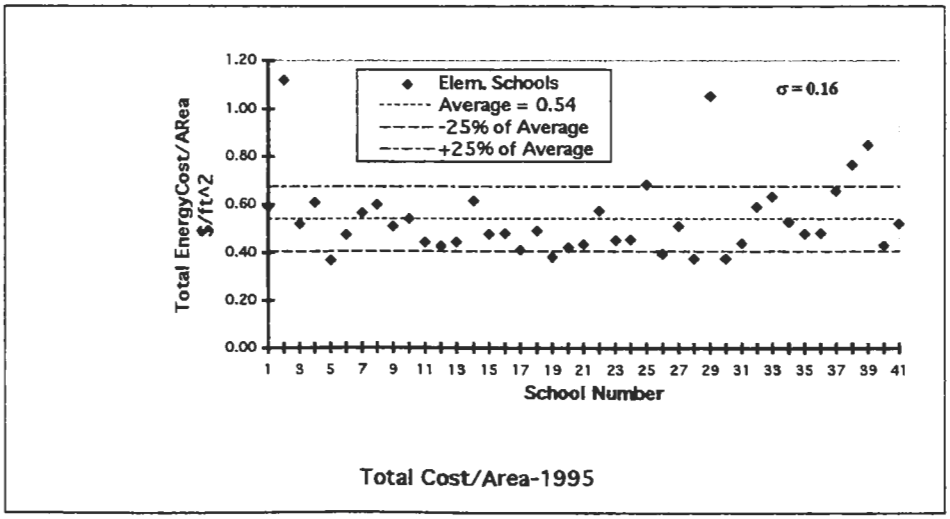
Fig. 3. Elementary School Energy Use



Electrical Cost/Area-1995

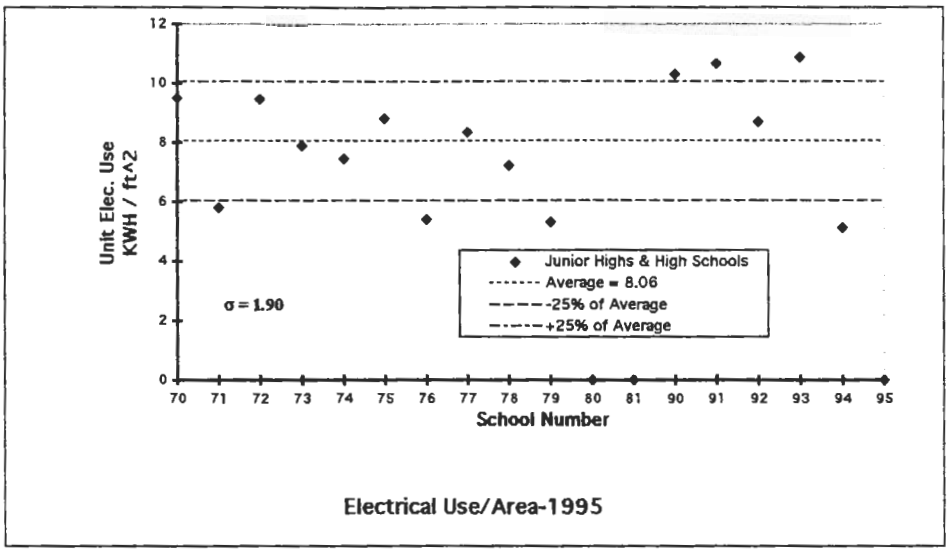


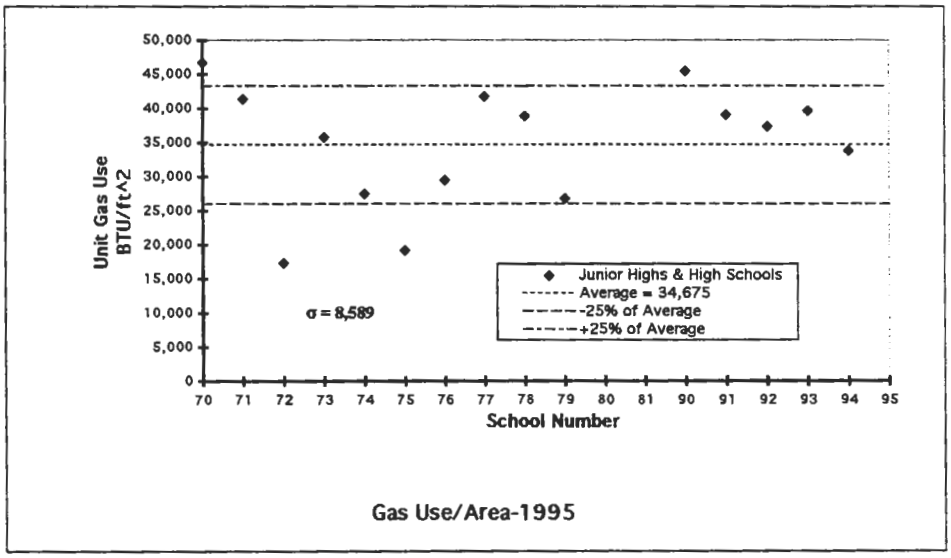
Gas Cost/Area-1995



Total Cost/Area-1995

Fig. 4 Elementary School Energy Cost





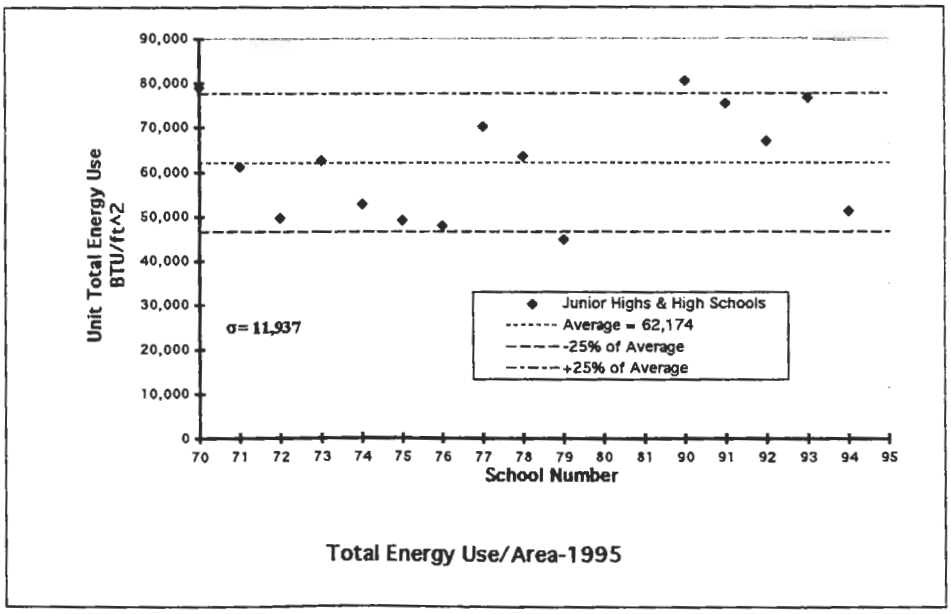
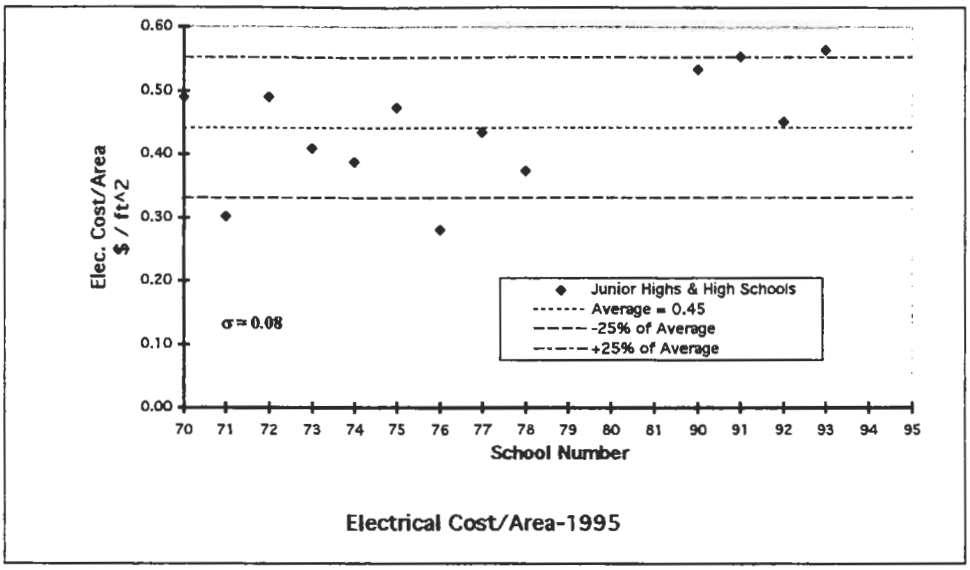
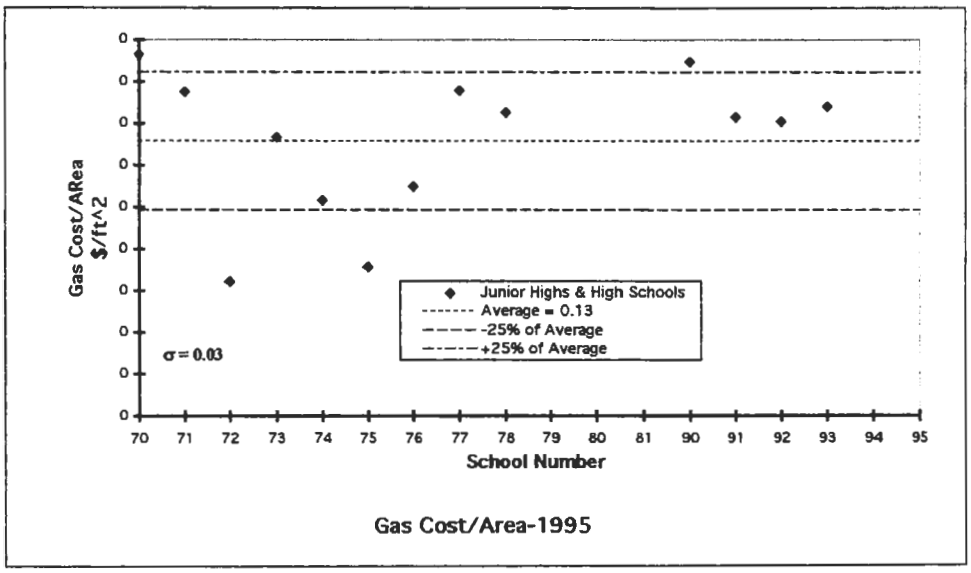


Fig. 5. Jr. Sr. High School Energy Use/Area





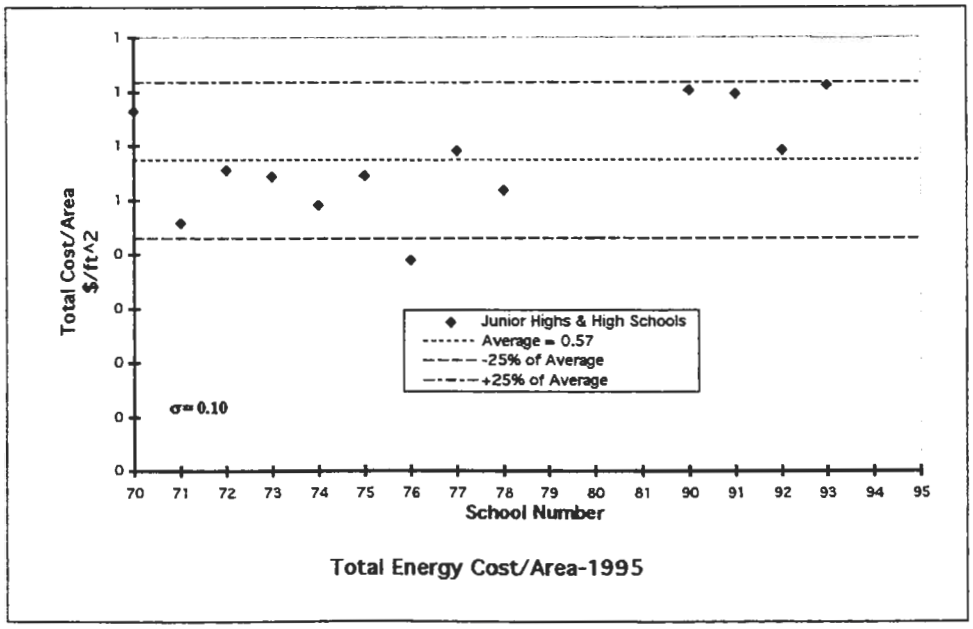


Fig. 6. Jr. and Sr. High Energy Cost/Area

Table II. Energy Use and Cost Data Summary: Elementary Schools

Elementary Schools Number of Schools	41		
	Low	**Average**	**High**
Area (ft^2)	28,127	44,617	63,652
1995 Annual Energy Use			
Electrical Use/Area (kwh/ft^2)	5.52	8.24	16.84
Gas Use/Area (Btu/ft^2)	9,363	26,897	66,639
Total Energy Use/Area (Btu/ft^2)	32,699	55,034	124,131
Electrical Cost/Area ($/$ft^2$)	0.29	0.44	0.98
Gas Cost/Area ($/$ft^2$)	0.03	0.10	0.24
Total Cost/Area ($/$ft^2$)	0.37	0.54	1.12

Table III. Energy Use and Cost Data Summary: Middle and Senior High Schools

Middle & Senior High Schools Number of Schools	14		
	Low	**Average**	**High**
Area (ft^2)	97,087	153,348	288,432
1995 Annual Energy Use			
Electrical Use/Area (kwh/ft^2)	5.14	8.06	10.87
Gas Use/Area (Btu/ft^2)	17,405	34,675	46,659
Total Energy Use/Area (Btu/ft^2)	44,856	62,174	80,623
Electrical Cost/Area ($/$ft^2$)	0.28	0.50	1.24
Gas Cost/Area ($/$ft^2$)	0.06	0.13	0.17
Total Cost/Area ($/$ft^2$)	0.39	0.57	0.71

It is seen that there is a wide variation in values of key energy characteristics. While certainly a large part of the variation is directly related to the size variation and range of school configurations among the responding facilities, the degree of use of high efficiency energy conversion equipment is also a contributing factor. It is first noted that for the elementary schools, while the areas differed by a factor of approximately 2.26, the maximum and minimum unit electrical and gas use per unit area varied by factors of 3.05

and 7.12 respectively. Another example of the variation of the data is seen in the values of the ratio of standard deviation to the average of the energy index which ranged from .28 to .37 for unit energy use. These ranges are particularly significant when it is understood the over 80% of the data was from the schools in one town. The unit electrical and gas cost per unit area varied by factors of 3.38 and 8 respectively.

The range of variation between maximum and minimum values was noticeably smaller for middle school/high school group with electrical and gas use/area varying by factors of only 2.11 and 2.68 respectively while electrical and gas cost per unit area varied by factors of 4.43 and 2.83. However, even the smaller ranges of unit energy use and costs would suggest the possibility of identifying viable energy conservation measures applicable to those facilities. In selected instances, the reason for higher than average energy use was easily identified. In one case, a facility with significantly higher energy use was identified as being the only facility having a therapeutically heated pool for senior citizen use. In other cases, variations in energy use was clearly due to the age and type of climate control equipment and the design of the school building.

Of the four responding school districts, only the two larger districts, Lubbock and Katy, were found to have been operating with a comprehensive energy conservation/ energy management program in recent years. However, based on the range of variations seen in the data even from these school systems, it would seem that a comprehensive energy conservation/energy management program does not by itself provide the lowest possible energy use.

Energy Use and Costs for Hospitals

Similar energy use and cost data were obtained and documented for approximately 35 hospitals as a part of the program funded by SECO. The participating facilities were located thoughout the state as shown in Figure 7. Figures 8 - 10 show the results of the energy performance tabulation from the hospital energy data obtained in this effort. Also shown on these figures are lines indicating ± 25% of the average values for each index.. It appears that the gas energy use and costs/area generally falls within a more narrow range with a few institutions having large variations as compared to the more widely spread variations for electrical energy use/area. It is also noted that in each case a variation of one standard deviation is greater than the ± 25% boundaries. Again it is seen that there is a wide variation in the values of key energy use and cost performance indices. The large variations in unit electrical and gas energy costs shown in Figure 10 are also interesting and were somewhat of a surprise to the author. These certainly contribute to the degree of variation in energy use and costs seen in Figures 8 and 9. While most of the unit electrical

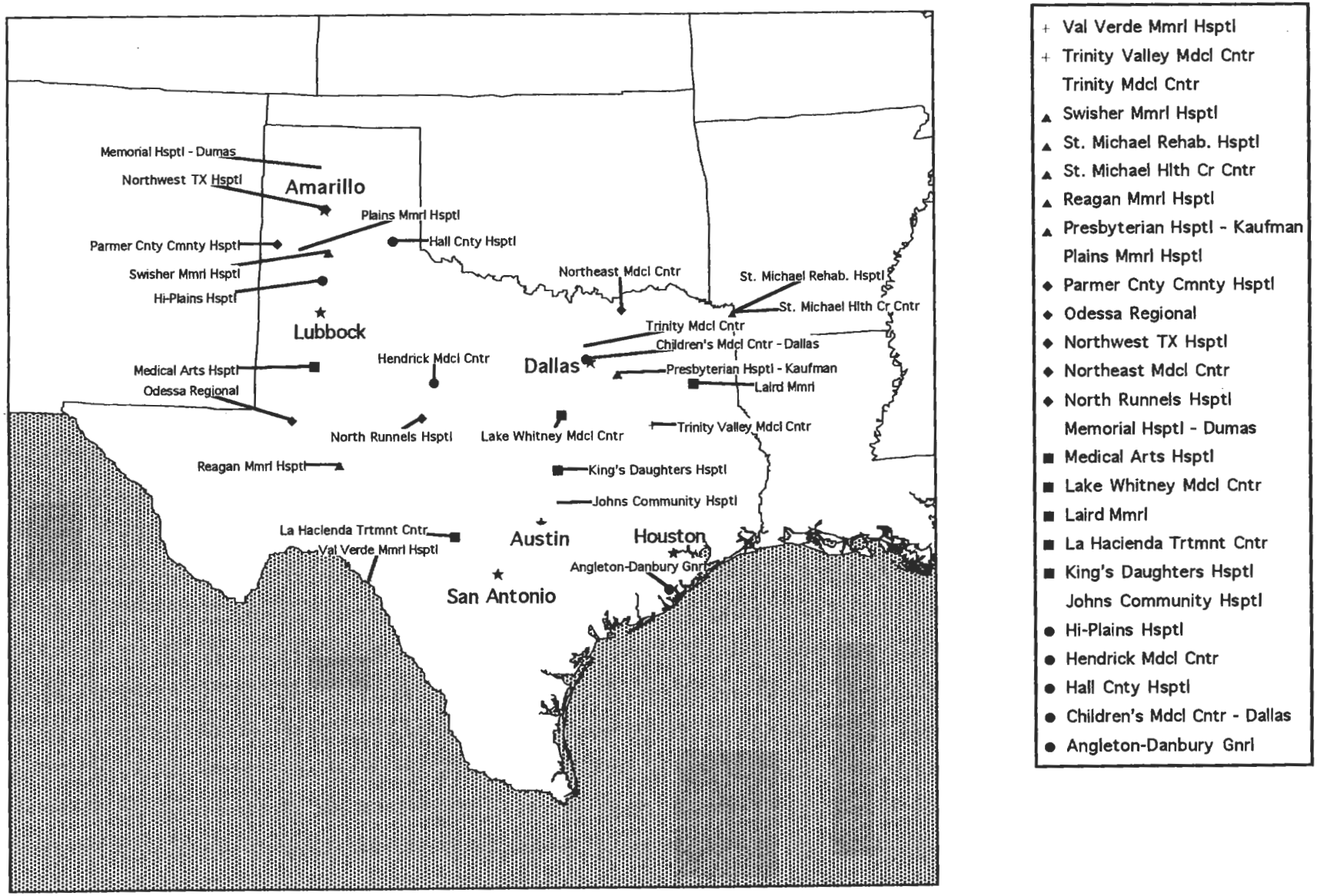
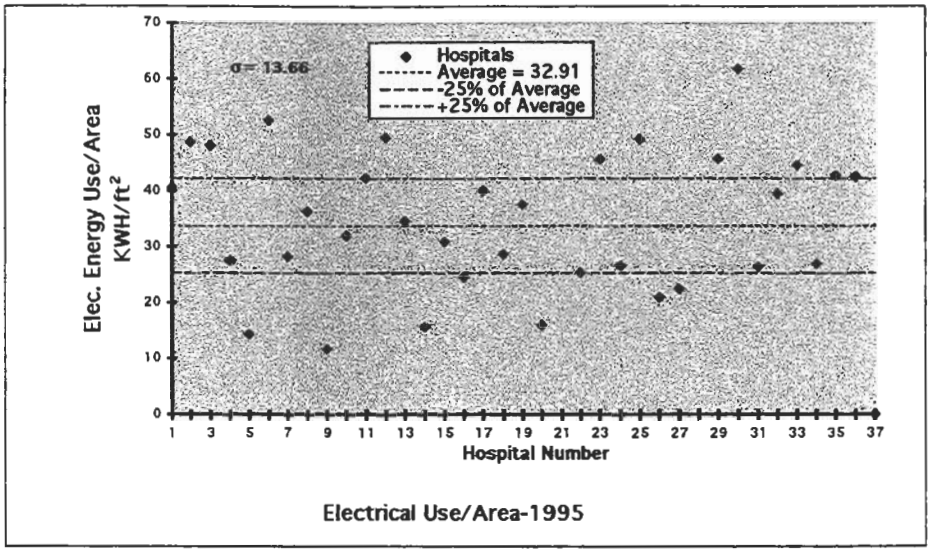
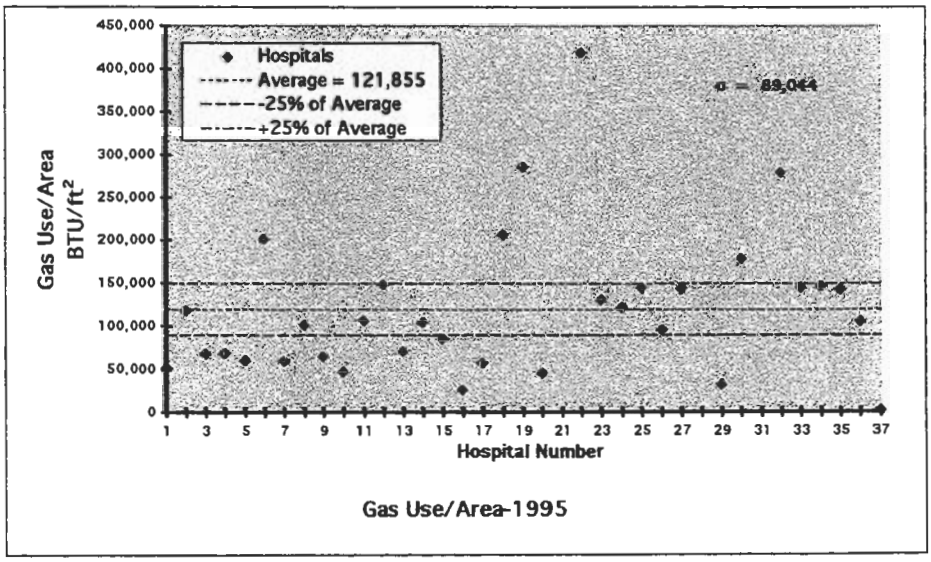


Fig. 7. Locations of Hospital Data Received





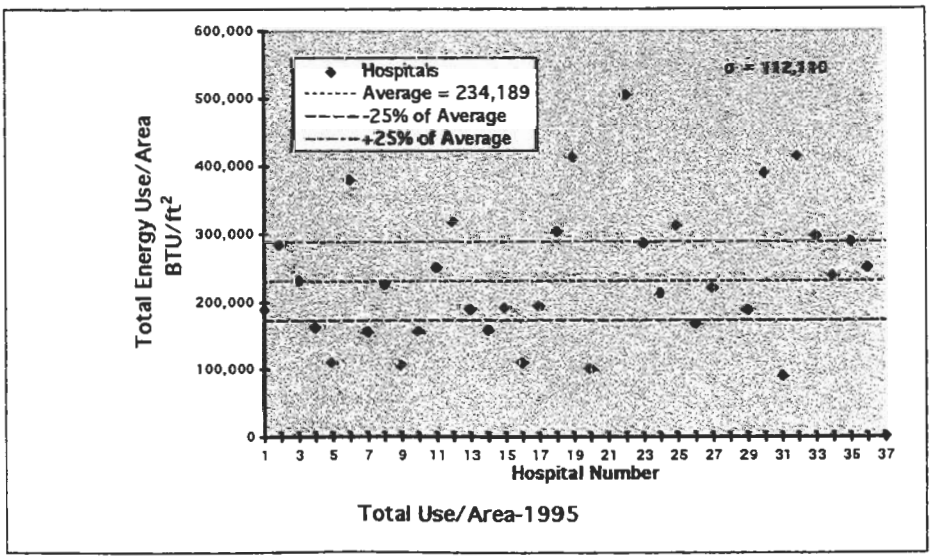
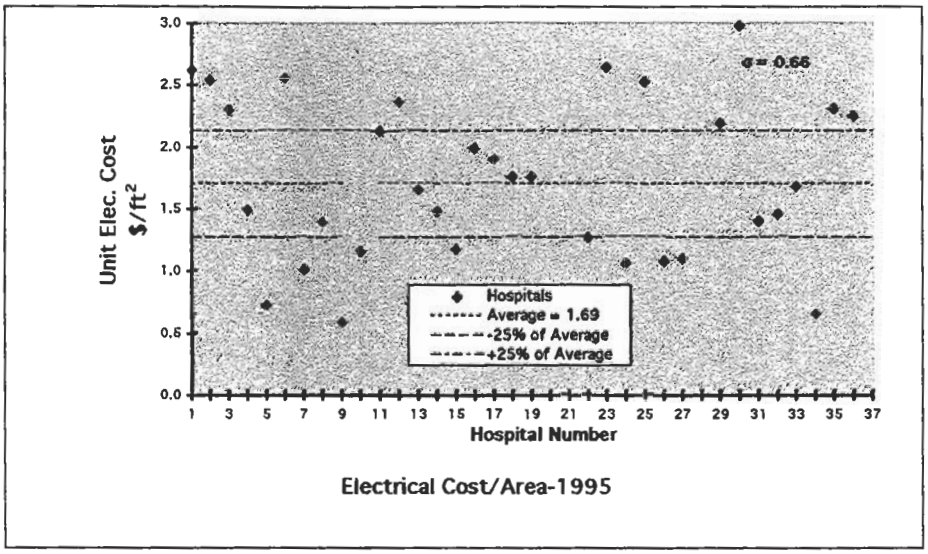
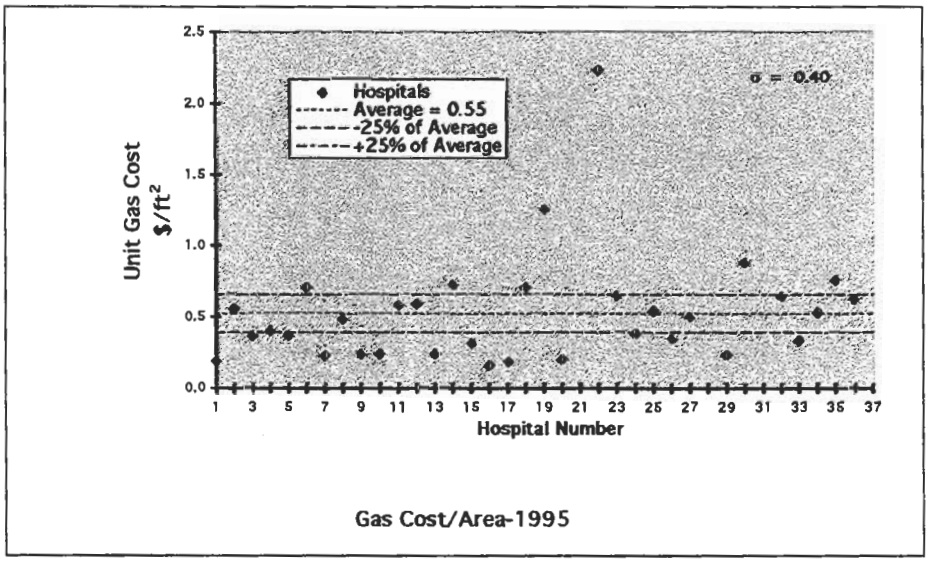


Fig. 8. Hospital Energy Use / Area





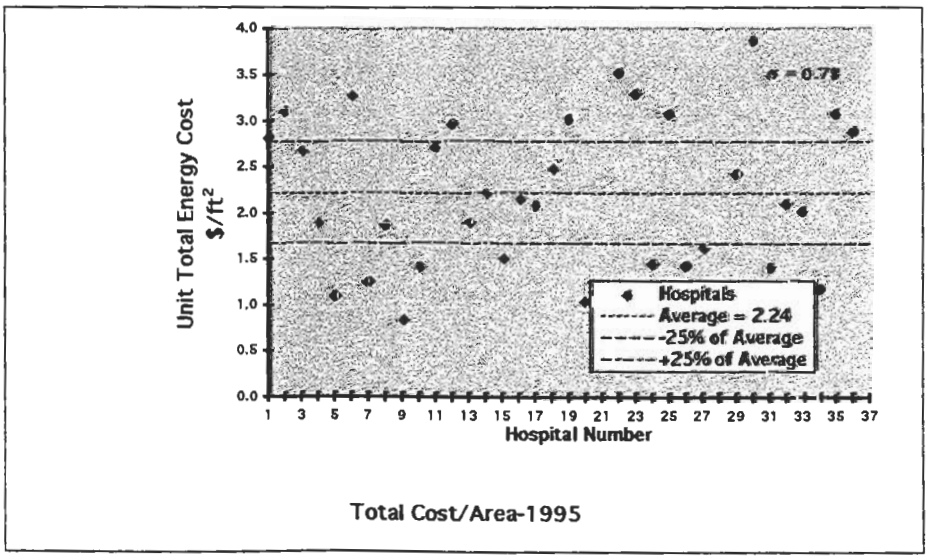
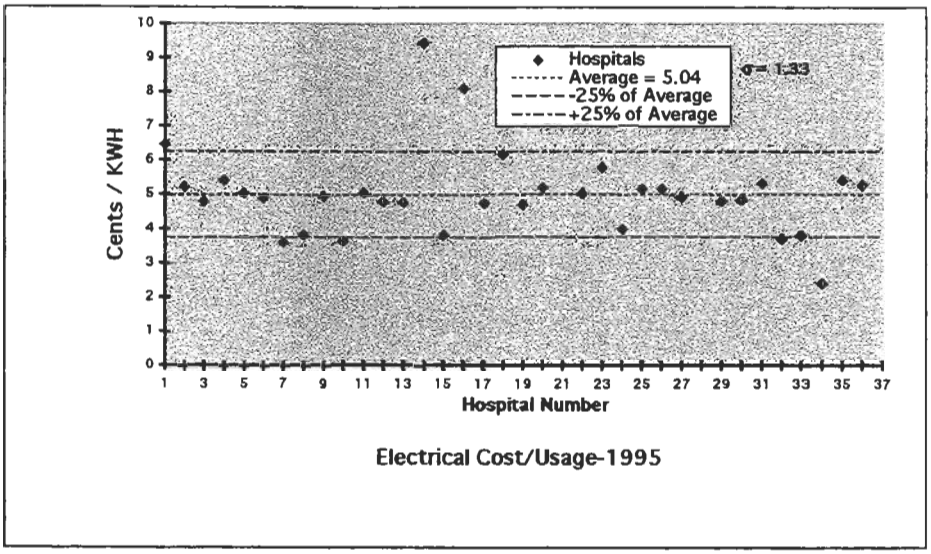


Fig. 9. Hospital Energy Costs/Area



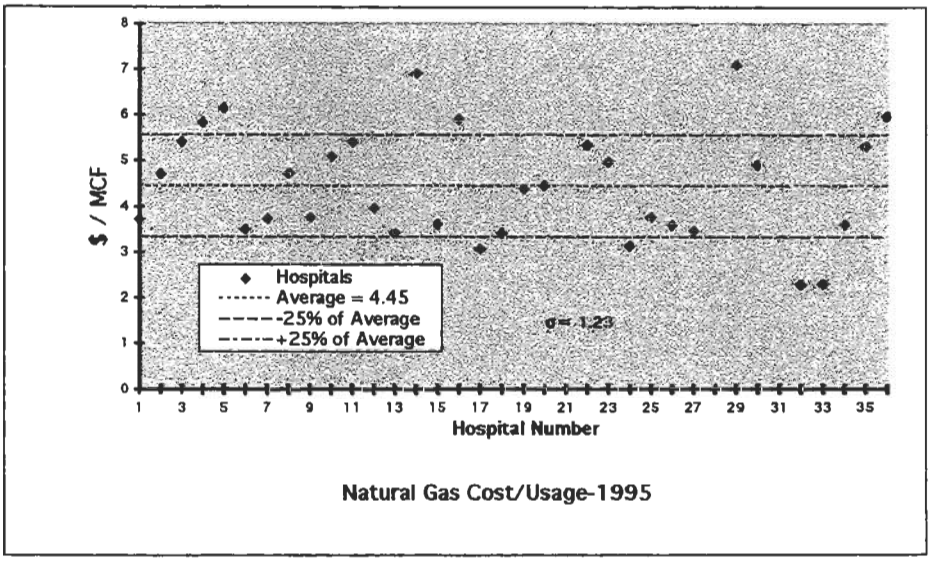


Fig. 10. Hospital Unit Energy Costs/Area

costs were close to 5 ¢/kwh, there appears to be a much greater variation in the unit gas costs for the participating facilities. It is noted that unit costs shown in Figure 10 are the total annual costs for each energy element including supplementary charges such as demand costs and fuel charges. At least one facility was found to typically have demand charges greater than 50% of the total electrical bill, but the data for this facility was not included since a completed data set was never provided. These variations are summarized in Table IV. While the size (conditioned area) of the responding facilities varied by a factor of 42, the annual electric energy use/area varies by a factor of 5.3, the gas use/area by 16, the total energy use/area by 5.04, the electric cost/area by 5.14, the gas cost/area by 14 and the total cost/area by 4.7.

Table I. Questionnaire and Energy Performance Summary

	Low	Average	High
Area (ft^2)	15,000	143,300	634,086
Age of Equipment (yrs)	1	21.2	46
1995 Annual Energy Use & Costs			
Electrical Use/Area (kwh/ft^2)	11.67	34.81	61.89
Gas Use/Area (Btu/ft^2)	26,192	123,150	418,267
Total Energy Use/Area (Btu/ft^2)	100,175	242,812	504,930
Electrical Cost/Area ($/$ft^2$)	0.58	1.71	2.98
Gas Cost/Area ($/$ft^2$)	0.16	0.53	2.23
Total Cost/Area ($/$ft^2$)	0.82	2.25	3.86

While it was not a part of the project for which this data was compiled, it is felt that expanding the data base to provide a more statistically accurate evaluation of this information and attempting to group the results by size and type of institution would be of great interest to state hospital personnel.

Conclusions

It is felt that the energy use and cost documentation and performance index presentation procedures are simple and easy to implement and the resulting energy performance charts would be an important part of a comprehensive energy management program. While the data base for the school energy use and cost data is too small to be statistically significant, the results of the hospital energy use and cost documentation were of great interest to the participants in the Hospital Energy Management Seminars presented in the SECO project and seem to be the first such comparisons for Texas hospitals seen by the participants. It is

hoped that a mechanism can be identified to the energy documentation methods and information presented in this paper to a larger segment of the schools and hospitals in the state.

Acknowledgments

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