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REDUCING ENERGY COSTS IN THE TEXAS STATE AGENCIES: CONSERVATION AND POLICY OPTIONS

Vol. 2 - Final Report

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TEXAS STATE AGENCIES: CONSERVATION AND POLICY OPTIONS

Vol. 2 - Final Report

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Chapter 1

AGENCY ENERGY CONSUMPTION DATA

The utility bills for the state agencies in FY '83 exceeded $250,000,000. Facing rising electrical rates and possibly decreased state revenues as a result of the recession, the governor's office needed to have a better understanding of the utility expenditures at the state agencies. The starting place was an accounting of the energy consumption and costs for the major energy consumers. Working with the Energy Management Group in the Department of Mechanical Engineering at Texas A&M University, the governor's budget office prepared forms for each state agency to complete. Each agency was asked to designate an energy manager, who would work directly with the governor's budget people in the energy area.

Letters were then sent to each state agency requesting data the past three fiscal years. The data were requested by March 15, 1984. Copies of the forms were then sent to the ME Department at A&M for analysis. The energy consumption is reported as the Energy Utilization Index (EUI) which has units of Btu/sf/year. The cost data are reported as the Energy Cost Index (ECI) and is reported as $/sf/year. The agencies were to report their square footage and do the conversions from kilowatt hours, cubic feet of natural gas, etc, following the guidelines on the form.

There were numerous problems encountered with the state energy data. The agency energy managers were generally not technical people, and they made numerous errors in the data. Many of the agencies were months late in transmitting the forms to the Governor's office. In some cases, agency data never did arrive. The reporting forms requested "conditioned" square feet. Most agencies did not have or attempt to get this number and used instead the "gross" square footage. The gross square footage includes many square feet of unconditioned space, including building overhangs, barns, and unconditioned parking garages. Some agencies used net square footage, which excludes such conditioned spaces as hallways and restrooms. The authors of this report obtained copies of the agency building square footage from the State Facilities Construction and Space Maintenance Division, and attempted to correct the data to a common area, that of gross square feet. Conversion errors, omitted data, and obvious erroneous data were corrected.

The various energy managers contacted by the A&M ME Department were very cooperative and quickly supplied any additional data requested. One problem which surfaced again and again in the discussions with the agency energy managers was the state's method of funding for utility expenses. The current practice is to fund the dollars for utilities as a separate item from agency capital and operations expenses. The utilities funding cannot be used for conservation; thus expenditures for conservation must be taken from either the operating or capital expenditures budgets. Although some agencies have allocated money for conservation, there is no motivation to do so. Any money saved through conservation practices would reduce utility expenditures but would simply be returned to the state at the end of the fiscal year. The present method of funding the utilities budget is actually a detriment to conservation.

As a result of the corrections made subsequent to the submittal of the forms by the state agencies, some of the data reported in Tables 1, 2, and 3 may be different from the original data submitted to the Governor's Budget Office. Tables 1, 2, and 3 reflect the most accurate and up-to-date data which could be obtained from the agencies, using agency gross square feet as the divisor.

Some interpretation and explanation of the data in Tables 1, 2, and 3 should be made. It is an unfair comparison to lump all the agencies into one group and just compare their energy consumption and energy cost. For instance, Texas A&M and the University of Texas at Austin are cogenerating universities. They buy enormous amounts of natural gas and burn it to produce electricity, steam, and chilled water for their campuses. Their energy utilization index will be higher because they produce electricity and have to suffer some thermal losses because of the conversion efficiency. Some agencies purchase their steam and chilled water, usually from an independent thermal source. Since they are purchasing a "finished product", one in which the supplier has had to pay the energy costs and conversion penalties to produce it, their energy costs will be higher. In order to compare like agencies, the authors decided on the following three main classifications:

A. Major Health Centers/Hospitals with Two Sub-Classifications

   1. Those which produce their own thermal energy
   2. Those which purchase their thermal energy

B. Universities with Three Sub-Classifications

   1. Cogenerating universities
   2. Universities which purchase their thermal energy

3. **Universities which produce their own thermal energy**

C. **Remaining State Agencies**

The logic behind the three main classifications was to be able to compare the agencies on a fairer basis. Major health centers and hospitals have 24-hour energy needs that most universities and state agencies, whose energy needs are primarily daytime, do not have. The sub-classifications distinguishing between purchased and produced energy is necessary, again for comparative purposes. There is perhaps justification for a further subdivision in the state agencies to distinguish the typical office operation from that of an industrial operation encountered at many of the prison units. However, there are unique features at many of the agencies, and it was decided by the authors to lump the remaining agencies into a single classification. Tables 1, 2, and 3 have no correction for climatic variations and represent agency energy data as reported, unless errors were discovered. The EUI's and ECI's are conservative, since there are many square feet of unconditioned space included in the areas. In fact, the energy consumption per conditioned square foot, i.e., "actual" energy consumption, is anywhere from 10% to 30% more than the EUI values listed. Similarly, the costs per conditioned square foot are much higher than shown.

Table 1 lists the major energy-consuming agencies based on the 1981 EUI. The ECI's are also noted in Table 1. There are some very large variations in energy consumption per square foot among the grouped agencies.

Discussion of Health Science Center/Hospitals

Health Centers Which Produce Thermal Energy

The FY '83 energy consumption at the San Antonio State Chest Hospital is nearly double that of any of the other agencies in this category. Furthermore its energy consumption from 1981 to 1983 increased 14%! The energy cost per square foot per year ranged from a low of $1.40 at Terrell State Hospital to a high of $3.53 at the San Antonio State Chest Hospital. Because the hospitals require thermal energy 24 hours a day, and because they need more outside air for ventilation purposes, it is reasonable to expect an energy consumption higher than an office building, for instance, with daytime-only operation. Of the eight hospitals listed in this category, three showed significant increases in energy consumption from 1981-83, three showed significant decreases in energy consumption, and two were essentially unchanged. In all instances, however, the

Table 1 - List of Agencies/Institutions Ranked According to their 1981 Energy Utilization Index.

LIST OF AGENCIES BASED ON THE 1981 EUI

AGENCY	"E U I" Btu/sf/yr 1981	1982	1983	"E C I" $/sf/yr 1981	1982	1983
MAJOR HEALTH CENTERS/HOSPITALS (PRODUCE THERMAL ENERGY)						
SAN ANTONIO STATE CHEST HOSPITAL	448097	493395	512860	2.22	3.16	3.53
WICHITA FALLS STATE HOSPITAL	279686	261349	255249	1.33	1.6	1.68
RUSK STATE HOSPITAL	263906	219929	223968	1.36	1.49	1.74
U T HEALTH CENTER AT TYLER	257278	326127	300748	1.32	2.11	2.12
TERRELL STATE HOSPITAL	246306	207672	209931	1.2	1.29	1.4
AUSTIN STATE HOSPITAL	219935	239568	274447	1.56	1.98	2.23
SOUTH TEXAS HOSPITAL	189226	181130	179646	1.57	1.95	2.24
SAN ANTONIO STATE HOSPITAL	171969	173933	173365	1.06	1.4	1.52
(PURCHASE THERMAL ENERGY)						
TEXAS TECH HEALTH SCIENCES CENTER	358528	340124	343310	3.14	3.37	4.22
U T HEALTH CENTER AT HOUSTON	482598	473390	474002	4.77	5.37	5.75
U T HEALTH SCIENCE AT DALLAS	401484	372575	371610	3.74	3.81	4.14
U T MEDICAL BR. GALVESTON	391910	376277	391978	3.1	3.66	4.16
U T SYSTEM CANCER CENTER	324354	291131	280792	3.02	3.57	3.75
U T HEALTH SCIENCE CENTER AT SAN ANTONIO	267801	277837	240979	2.24	2.89	2.88
UNIVERSITIES						
COGENERATING						
TEXAS A&M UNIVERSITY	430417	422386	380761	1.26	1.68	1.78
UNIVERSITY OF TEXAS AT AUSTIN	430385	460588	473210	1.55	1.91	2.25
PURCHASE THERMAL ENERGY						
U H UNIV. PARK (PHARMACY BLDG.)	367477	379137	335266	3.73	4.36	4.37
U T PERMIAN BASIN	287223	290216	243476	2.45	2.75	2.79
U T SAN ANTONIO	211047	233985	223073	2.6	2.88	3.25
TWU HOUSTON CAMPUS	184557	216634	317456	2.37	2.63	3.68
PAN AMERICAN UNIVERSITY	182640	201482	205268	2.32	2.69	3.14

Table 1 (cont.)

U T DALLAS	169454	166232	160134	2.62	2.75	2.83
TEXAS TECH UNIVERSITY	168000	161306	164097	1.02	1.18	1.36
UT EL PASO	125953	120305	134653	1.47	1.5	1.84
U T TYLER	111354	206014	130533	1.02	1.17	1.36
PRODUCE THERMAL ENERGY						
TEXAS A&M UNIVERSITY AT GALVESTON	326270	338592	236686	3.02	3.73	3.28
SOUTH WEST TEXAS STATE UNIVERSITY	274088	296196	270007	1.38	1.76	1.83
TWU DENTON CAMPUS	262400	263455	247273	1.18	1.53	1.51
PRAIRIE VIEW A&M UNIV.	243744	229204	267337	1.36	1.57	1.75
U H - UNIVERSITY PARK	239449	260404	287726	1.63	2.3	2.67
TEXAS SOUTHERN UNIVERSITY	223232	249933	269473	1.81	2.07	2.15
U T ARLINGTON	216787	234396	215050	1.2	1.61	1.63
U H - CLEAR LAKE	199338	209179	193365	1.92	2.51	2.56
STEPHEN F.AUSTIN UNIVERSITY	174398	159236	155124	1.17	1.29	1.37
LAMAR UNIVERSITY	150258	152582	145115	1.01	1.22	1.42
TWU DALLAS CAMPUS	147670	137871	151467	1.3	1.43	1.58
NORTH TEXAS STATE UNIVERSITY	137076	131371	131335	1.67	1.39	1.47
MID WESTERN STATE UNIVERSITY	129700	114246	119984	0.86	0.98	1.08
WEST TEXAS UNIVERSITY	129450	128616	122732	0.75	0.85	0.92
SAM HOUSTON STATE UNIV.	115383	99835	99123	0.91	0.92	1.04
ANGELO STATE UNIVERSITY	113965	111159	108714	0.79	1.09	1.24
TARLETON STATE UNIV.	107844	102583	97700	0.82	0.93	0.92
CORPUS CHRISTI STATE UNIVERSITY	102003	92004	97378	1.39	1.46	1.69
U T INSTITUTE OF TEXAN CULTURES	94071	129128	104708	0.85	1.27	1.25
TEXAS A&I UNIVERSITY	89809	86907	83680	0.95	1.13	1.22
U H - DOWNTOWN	72645	95980	99532	0.83	1.32	1.52
EAST TEXAS STATE UNIV. TEXARKANA	65351	76435	64636	0.57	0.74	0.84
U H - VICTORIA	51421	55133	65499	0.73	1.04	1.15
SUL ROSS STATE UNIVERSITY	------	232296	233538	1.07	1.47	1.66
MAJOR STATE AGENCIES						
TDC COFFIELD UNIT	349822	319838	270861	1.82	2.04	2.12
ABILENE STATE SCHOOL	339892	338236	258138	1.44	1.75	1.81
TDC DARRINGTON UNIT	338923	364573	214986	1.56	2.06	1.49
TDC GOREE UNIT	313655	317031	337589	1.65	1.97	2.48
TDC CLEMENS UNIT	306559	233638	218232	1.43	1.41	1.46
TDC EASTHAM UNIT	267177	265430	270238	1.19	1.46	1.81

Table 1 (cont.)

TDC RAMSEY UNIT	263718	273719	239241	1.36	1.76	1.68
TDC WYNNE,DIAGNOSTIC&WINDHAM UNITS	257508	257284	259005	1.31	1.55	1.92
TDC RETRIEVE UNIT	251180	314586	273992	1.35	2.01	1.93
TDC HUNTSVILLE UNIT	246169	243790	244678	1.44	1.71	2.08
RICHMOND STATE SCHOOL	242666	234365	215896	1.65	2.1	2.05
TDC CENTRAL&JESTER UNITS	242470	229646	316255	1.15	1.38	1.94
TDC FERGUSION UNIT	236944	276772	276612	1.07	1.53	1.87
STATE PURCHASING&GEN. SER.COMMISSION	217538	182089	159733	1.11	1.34	1.42
TEXAS DEPT. OF HEALTH	215836	209786	197673	1.2	1.87	1.74
TDC ELLIS UNIT	215461	232763	236994	1.07	1.36	1.7
T D M H M R	214497	204818	200618	1.28	1.54	1.66
DENTON STATE SCHOOL	204974	202848	175603	1.42	1.68	1.5
AUSTIN STATE SCHOOL	167370	168322	175339	1.23	1.56	1.61
ADJUTANT GENERAL'S DEPT.	166275	177734	180703	2.16	2.49	2.49
TRAVIS STATE SCHOOL	155237	152824	154236	1.28	1.54	1.56
MEXIA STATE SCHOOL	147893	132774	141258	0.95	1.08	1.24
TDC MT.VIEW GATESVILLE UNITS	141346	140376	180632	0.88	1.06	1.56
TEXAS DEPT. OF PUBIC SAFETY	124175	116455	96345	1.01	1.11	1.5
STATE DEPT. OF HWYS&PUBLIC TRANS.	119086	121378	132790	1.21	1.59	1.78
TEXAS EMPLOYMENT COMMISSION	98791	120635	119269	1.21	1.51	1.49
TEXAS PARKS &WILDLIFE	95296	102948	97807	0.93	1.08	1.15
TEXAS DEPT. OF HUMAN RESOURCES	89969	87321	92126	1.43	1.89	1.55
TEXAS DEPT. OF COMMUNITY AFFAIRS	84478	100617	78696	1.47	1.84	1.96
TEXAS REHABILT. COMMISSION	65029	66426	60906	1.84	2.35	2.75
TDC PACK I UNIT	-----	-----	163829	----	----	1.14
TDC PACK II UNIT	-----	-----	231266	----	----	1.51

energy costs rose, despite some obvious energy reductions.

Health Centers Which Purchase Thermal Energy

The highest energy costs per square foot occur at the Health Science Centers which purchase their thermal energy. The UT-Houston, Galveston, Dallas and Texas Tech Health Centers all had energy costs exceeding $4.00 per square foot in FY '83. As previously discussed, when an agency purchases thermal energy, they are paying more for that energy. As an example, the TT Health Sciences Center purchases thermal energy from the TT physical plant. The cost of the steam includes the price of the natural gas burned, the steam distribution lines, the manpower required to produce it, and the capitalization of their plant equipment. The same is true for the chilled water. Part of the cost is associated with the chillers, pumps, and people as well as the electrical costs associated with producing the chilled water. Furthermore, there is a higher conversion energy associated with the production of chilled water, and the EUI's will be higher as a result. Also, for those agencies who produce their own thermal energy, the cost figures do not reflect the cost of labor or equipment, only energy! Direct comparisons of energy consumption and cost between the two sub-classifications, therefore, cannot be made. Comparisons of cost and consumption within the classifications should be valid. The cost index varies from $2.88 to $5.75 per square foot per year. The combined price of energy (steam and chilled water) is about the same at all the health science centers; therefore the variation in cost can be attributed directly to the energy consumption per square foot. Some significant dollar savings can result in these institutions because of their higher cost of energy. Conservation measures employed in these institutions have a potentially greater rate of return on the conservation investment.

Universities

Co-generating Universities

Referring to Table 1, there are two universities which are cogenerators. Both Texas A&M and UT-Austin purchase large quantities of natural gas which they burn to produce electricity, steam, and chilled water. Their energy consumption is high because they lose a significant portion of the primary energy (i.e., gas) to produce electricity; however, because some of the thermal energy is utilized in campus heating and cooling, a portion of the conversion losses can be recovered. From a cost standpoint, both universities are providing energy at a fairly cheap rate. The costs and energy consumption at Texas A&M are considerably less than at UT-Austin. The trends are also significantly different. A&M has reduced unit energy consumption by 11% from 1981-83, while UT has increased their unit consumption by 10%. Because of the size of these two huge campuses, tremendous opportunities exist for energy conservation and the resultant savings in energy dollars.

Universities Which Purchase Thermal Energy

Universities in this category, as with the health science centers, will pay a premium for their energy because they are purchasing a "refined" product. Excluding the UH Pharmacy Building and the TWU Houston Campus, all of these universities fall within the 100,000 to 250,000 Btu/sf/yr range. UT-Dallas, UT-El Paso, and UT-Tyler have very low energy consumption, particularly for institutions which purchase their thermal energy. Concerted efforts to save energy are obviously occurring at these campuses. The UH Pharmacy Bldg. and TWU Houston campuses are out-of-line with the other institutions. TWU Houston campus' energy consumption, for instance, increased 72% from 1981 to 1983.

Universities Which Produce Their Thermal Energy

The bulk of the state universities in Texas operate their own thermal plants and are listed as producers of their own thermal energy. Theoretically these universities should have the lowest energy consumption per square foot and the lowest energy cost index. Only utility charges, i.e., cost of electricity and natural gas are included in the energy costs. Manpower to run the plants and maintain the distribution lines are not reflected in the energy costs. The principal losses in energy are those associated with producing steam in the boiler and in the conversion of the gas/electricity to provide chilled water.

As noted in Table 1, there is a huge variation among the universities in both energy costs/square foot and consumption/square foot. Several of the universities have energy consumptions, campus-wide, of less than 100,000 Btu/sf/yr, while others approach or exceed 300,000 Btu/sf/yr. While there are a few notable exceptions, most of the universities exhibit little or no conservation effort from 1981-83, maintaining a fairly constant energy consumption. The unit energy costs for most are cheap, averaging between $1 and $1.60/sf/yr. Those established universities with EUI's less than 100,000 Btu/sf/yr, Texas A&I University, Corpus Christi State University, and Sam Houston State University apparently have some conservation program in-place. Modern energy-efficient buildings built today can expect EUI's of 50,000-75,000 Btu/sf/yr, depending on their application, and these three universities, with many old buildings, are approaching this value. Potential energy savings at these institutions are small compared to the top nine listed in Table 1. The EUI's for A&M-Galveston, Southwest Texas State, Lamar, TWU-Denton, Prairie View, UH, Southern, UT-Arlington, UH-Clear Lake, and Stephen F. Austin average around 250,000 Btu/sf/yr. The potential energy savings through conservation and sound energy management practices are large. These campus buildings, on the average, consume five times the energy per square foot of an energy efficient building built to current state-of-the-art practices.

Major State Agencies

The energy data for the remaining major state agencies and some of the units within these agencies are listed in Table 1. As mentioned earlier, it is perhaps unfair to list the prison units along with the other state agencies. Many of the units have manufacturing processes/light industry which will make them more energy intensive. For the most part, however, there is no air conditioning in these units, and this may help balance out the industrial energy requirements. With few exceptions, most of the agencies average a unit consumption of around 200,000 Btu/sf/yr or more. The potential for conservation savings exists at most of the state agencies.

Tables 2 and 3 are different representation of the data contained in Table 1. Table 2 lists several agencies and their respective units in alphabetical order. Table 3 has the same listings as Table 1, except the base is the 1983 Energy Cost Index (ECI). With this table one can easily identify the agencies/ institutions which have the highest unit energy costs.

While the data shown in Tables 1-3 are an indication of current agency use, the data are not of sufficient duration to determine if the agency has an effective energy management or conservation plan in place. Long-term data are needed. Ten years of data are really needed to establish a baseline and a history. This recommendation was made to the governor's office, but the decision was made by them to request only the past three years of data. To illustrate why longer term data are needed, consider Table 4. Data from the 1973-75 period were obtained from a report prepared by the Governor's Energy Advisory Council Staff, dated January 1977. Not all the current agencies existed or were reported in the earlier report, and some of the earlier data were suspect. Those agencies/ universities in Table 4 are those which appear to

Table 2 - Alphabetical Listing of Several Major State Agencies

MAJOR AGENCIES

	"E U I" Btu/sf/yr			"E C I" $/sf/yr		
UNIVERSITY OF TEXAS SYSTEM	1981	1982	1983	1981	1982	1983
U T ARLINGTON	216787	234396	215050	1.2	1.61	1.63
U T AUSTIN	430385	460588	473210	1.55	2.91	2.25
U T DALLAS	169454	166232	160134	2.62	2.75	2.79
U T EL PASO	125953	120305	134653	1.47	1.5	1.84
U T HEALTH SCIENCE AT DALLAS	401484	372575	371610	3.74	3.81	4.14
U T HEALTH CENTER AT HOUSTON	482598	473390	474002	4.77	5.37	5.75
U T HEALTH SCIENCE AT SAN ANTONIO	267801	277837	240979	2.24	2.89	2.88
U T HEALTH CENTER AT TYLER	257278	326127	300748	1.32	2.11	2.12
U T INSTITUTE OF TEXAN CULTURES	94071	129128	104708	0.85	1.27	1.25
U T MEDICAL BR. GALVESTON	391910	284121	391978	3.1	3.66	4.16
U T PERMIAN BASIN	287223	290216	243476	2.45	2.75	2.79
U T SAN ANTONIO	211047	233985	223073	2.6	2.88	3.25
U T SYSTEM CANCER CENTER	324354	291131	280792	3.02	3.57	3.75
U T TYLER	111354	125983	130533	1.02	1.17	1.36
TEXAS WOMANS UNIVERSITY SYSTEM						
TWU DALLAS CAMPUS	147670	137871	151467	1.3	1.43	1.58
TWU DENTON CAMPUS	262400	263455	247273	1.18	1.53	1.51
TWU HOUSTON CAMPUS	184557	216634	317456	2.37	2.63	3.68
UNIVERSITY OF HOUSTON SYSTEM						
U H - CLEAR LAKE	199338	209179	80250	1.92	2.51	2.56
U H - DOWNTOWN	72645	95980	99532	0.83	1.32	1.52
U H - UNIVERSITY PARK	239449	260404	287726	1.63	2.3	2.67
U H - VICTORIA	51421	55133	65499	0.73	1.04	1.15
U H UNIV. PARK (PHARMACY BLDG.)	367477	379137	335266	3.73	4.36	4.37

Table 2 (cont.)

TEXAS DEPT. OF CORRECTIONS

CENTRAL &JESTER UNITS	242470	229646	316255	1.15	1.38	1.94
CLEMENS UNIT	306559	233639	214896	1.43	1.41	1.46
COFFIELD,BETO UNITS	349882	319838	270861	1.82	2.04	2.12
DARRINGTON UNIT	338923	364573	214896	1.56	2.06	1.49
EASTHAM UNIT	267177	265430	270238	1.19	1.46	1.81
ELLIS UNIT	215461	232763	236994	1.07	1.36	1.7
FERGUSION UNIT	236944	276772	276612	1.07	1.53	1.87
GOREE UNIT	313655	317031	337589	1.65	1.97	2.48
HUNTSVILLE UNIT	246169	243790	244678	1.44	1.71	2.08
MT.VIEW GATESVILLE UNITS	141346	140376	180632	0.88	1.06	1.56
PACK I UNIT	------	------	163829	------	------	1.14
PACK II UNIT	------	------	231266	------	------	1.51
RAMSEY UNIT	263718	273719	239241	1.36	1.76	1.68
RETRIEVE UNIT	251180	314586	273992	1.35	2.01	1.93
WYNNE,DIAGNOSTIC &WINDHAM UNITS	257508	257284	259005	1.31	1.55	1.92

T D M H M R

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AUSTIN STATE HOSPITAL	219935	239568	274447	1.56	1.98	2.23
AUSTIN STATE SCHOOL	167730	168322	17533	1.23	1.56	1.61
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RICHMOND STATE SCHOOL	242666	234365	215896	1.65	2.1	2.05
RUSK STATE HOSPITAL	263906	219929	223968	1.36	1.49	1.74
SAN ANTONIO STATE HOSPITAL	171969	173933	173365	1.06	1.4	1.52
TERRELL STATE HOSPITAL	246306	207672	209931	1.2	1.29	1.4
TRAVIS STATE SCHOOL	155237	152824	154236	1.28	1.54	1.56
WICHITA FALLS STATE HOSPITAL	279686	261349	255249	1.33	1.6	1.68

Table 3 - Listing of State Agencies/Institutions Based on the 1983 Energy Cost Index

LIST OF AGENCIES BASED ON THE 1983 ECI

AGENCY	"E U I" Btu/sf/yr 1981	1982	1983	"E C I" $/sf/yr 1981	1982	1983
MAJOR HEALTH CENTERS/HOSPITALS (PRODUCE THERMAL ENERGY)						
SAN ANTONIO STATE CHEST HOSPITAL	448097	493395	512860	2.22	3.16	3.53
SOUTH TEXAS HOSPITAL	189226	181130	179646	1.57	1.95	2.24
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U T HEALTH CENTER AT TYLER	257278	326127	300748	1.32	2.11	2.12
RUSK STATE HOSPITAL	263906	219929	223968	1.36	1.49	1.74
WICHITA FALLS STATE HOSPITAL	279686	261349	255249	1.33	1.6	1.68
SAN ANTONIO STATE HOSPITAL	171969	173933	173365	1.06	1.4	1.52
TERRELL STATE HOSPITAL	246306	207672	209931	1.2	1.29	1.4
(PURCHASE THERMAL ENERGY)						
U T HEALTH CENTER AT HOUSTON	482598	473390	474002	4.77	5.37	5.75
TEXAS TECH HEALTH SCIENCES CENTER	358528	340124	343310	3.14	3.37	4.22
U T MEDICAL BR. GALVESTON	391910	376277	391978	3.1	3.66	4.16
U T HEALTH SCIENCE AT DALLAS	401484	372575	371610	3.74	3.81	4.14
U T SYSTEM CANCER CENTER	324354	291131	280792	3.02	3.57	3.75
U T HEALTH SCIENCE CENTER AT SAN ANTONIO	267801	277837	240979	2.24	2.89	2.88
UNIVERSITIES						
COGENERATING						
UNIVERSITY OF TEXAS AT AUSTIN	430385	460588	473210	1.55	1.91	2.25
TEXAS A&M UNIVERSITY	430417	422386	380761	1.26	1.68	1.78
PURCHASE THERMAL ENERGY						
U H UNIV. PARK (PHARMACY BLDG.)	367477	379137	335266	3.73	4.36	4.37
TWU HOUSTON CAMPUS	184557	216634	317456	2.37	2.63	3.68
U T SAN ANTONIO	211047	233985	223073	2.6	2.88	3.25
PAN AMERICAN UNIVERSITY	182640	201482	205268	2.32	2.69	3.14
U T DALLAS	169454	166232	160134	2.62	2.75	2.83

Table 3 (cont.)

U T PERMIAN BASIN	287223	290216	243476	2.45	2.75	2.79
UT EL PASO	125953	120305	134653	1.47	1.5	1.84
TEXAS TECH UNIVERSITY	168000	161306	164097	1.02	1.18	1.36
U T TYLER	111354	125983	130533	1.02	1.17	1.36

PRODUCE THERMAL ENERGY

TEXAS A&M UNIVERSITY AT GALVESTON	326270	338592	236686	3.02	3.73	3.28
U H - UNIVERSITY PARK	239449	260404	287726	1.63	2.3	2.67
U H - CLEAR LAKE	199338	209179	193365	1.92	2.51	2.56
TEXAS SOUTHERN UNIVERSITY	223232	249933	269473	1.81	2.07	2.15
SOUTH WEST TEXAS STATE UNIVERSITY	274088	296196	270007	1.38	1.76	1.83
PRAIRIE VIEW A&M UNIV.	243744	229204	267337	1.36	1.57	1.75
CORPUS CHRISTI STATE UNIVERSITY	102003	92004	97378	1.39	1.46	1.69
SUL ROSS STATE UNIVERSITY	------	232296	233538	1.07	1.47	1.66
U T ARLINGTON	216787	234396	215050	1.2	1.61	1.63
TWU DALLAS CAMPUS	147670	137871	151467	1.3	1.43	1.58
U H - DOWNTOWN	72645	95980	99532	0.83	1.32	1.52
TWU DENTON CAMPUS	262400	263455	247273	1.18	1.53	1.51
NORTH TEXAS STATE UNIVERSITY	137076	131371	131335	1.67	1.39	1.47
LAMAR UNIVERSITY	150258	152582	145115	1.01	1.22	1.42
STEPHEN F.AUSTIN UNIVERSITY	174398	159236	155124	1.17	1.29	1.37
U T INSTITUTE OF TEXAN CULTURES	94071	129128	104708	0.85	1.27	1.25
ANGELO STATE UNIVERSITY	113965	111159	108714	0.79	1.09	1.24
TEXAS A&I UNIVERSITY	89809	86907	83680	0.95	1.13	1.22
U H - VICTORIA	51421	55133	65499	0.73	1.04	1.15
MID WESTERN STATE UNIVERSITY	129700	114246	119984	0.86	0.98	1.08
SAM HOUSTON STATE UNIV.	115383	99835	99123	0.91	0.92	1.04
TARLETON STATE UNIV.	107844	102583	97700	0.82	0.93	0.92
WEST TEXAS UNIVERSITY	129450	128616	122732	0.75	0.85	0.92
EAST TEXAS STATE UNIV. TEXARKANA	65351	76435	64636	0.57	0.74	0.84

MAJOR STATE AGENCIES

TEXAS REHABILT. COMMISSION	65029	66426	60906	1.84	2.35	2.75
ADJUTANT GENERAL'S DEPT.	166275	177734	180703	2.16	2.49	2.49
TDC GOREE UNIT	313655	317031	337589	1.65	1.97	2.48
TDC COFFIELD UNIT	349822	319838	270861	1.82	2.04	2.12
TDC HUNTSVILLE UNIT	246169	243790	244678	1.44	1.71	2.08
RICHMOND STATE SCHOOL	242666	234365	215896	1.65	2.1	2.05
TEXAS DEPT. OF COMMUNITY AFFAIRS	84478	100617	78696	1.47	1.84	1.96
TDC CENTRAL&JESTER UNITS	242470	229646	316255	1.15	1.38	1.94
TDC RETRIEVE UNIT	251180	314586	273992	1.35	2.01	1.93
TDC WYNNE,DIAGNOSTIC&WINDHAM UNITS	257508	257284	259005	1.31	1.55	1.92
TDC FERGUSION UNIT	236944	276772	276612	1.07	1.53	1.87
TDC EASTHAM UNIT	267177	265430	270238	1.19	1.46	1.81
ABILENE STATE SCHOOL	339892	338236	258138	1.44	1.75	1.81
STATE DEPT. OF HWYS&PUBLIC TRANS.	119086	121378	132790	1.21	1.59	1.78
TEXAS DEPT. OF HEALTH	215836	209786	197673	1.2	1.87	1.74
TDC ELLIS UNIT	215461	232763	236994	1.07	1.36	1.7
TDC RAMSEY UNIT	263718	273719	239241	1.36	1.76	1.68
T D M H M R	214497	204818	200618	1.28	1.54	1.66

Table 3 (cont.)

AUSTIN STATE SCHOOL	167370	168322	175339	1.23	1.56	1.61
TDC MT.VIEW GATESVILLE UNITS	141346	140376	180632	0.88	1.06	1.56
TRAVIS STATE SCHOOL	155237	152824	154236	1.28	1.54	1.56
TEXAS DEPT. OF HUMAN RESOURCES	89969	87321	92126	1.43	1.89	1.55
TDC PACK II UNIT	-----	-----	231266	----	----	1.51
TEXAS DEPT. OF PUBIC SAFETY	124175	116455	96345	1.01	1.11	1.5
DENTON STATE SCHOOL	204974	202848	175603	1.42	1.68	1.5
TEXAS EMPLOYMENT COMMISSION	98791	120635	119269	1.21	1.51	1.49
TDC DARRINGTON UNIT	338923	364573	214986	1.56	2.06	1.49
TDC CLEMENS UNIT	306559	233638	218232	1.43	1.41	1.46
STATE PURCHASING&GEN. SER.COMMISSION	217538	182089	159733	1.11	1.34	1.42
MEXIA STATE SCHOOL	147893	132774	141258	0.95	1.08	1.24
TEXAS PARKS &WILDLIFE	95296	102948	97807	0.93	1.08	1.15
TDC PACK I UNIT	-----	-----	163829	----	----	1.14

TABLE 4 - Comparison of Current Energy Consumption with 1973-75 for Selected State Agencies

STATE AGENCY	ENERGY UTILIZATION INDEX 1973	1974	1975	1981	1982	1983	%CHANGE 1973-1983
Department of Corrections	315489	265628	307860	253518	250632	251778	-20.2
Department of Health Resources	258573	243336	253745	215836	209786	197673	-23.6
Dept. of Men. Health & Men. Re	249045	228793	232381	214497	204497	200618	-19.4
Texas Employment Commission	134697	95849	118686	98791	120635	119269	-11.5
Department of Public Safety	133599	93279	110581	124175	116455	96345	-27.9
Dept. of Highways & Pub. Tran's	118533	89993	105623	119086	121378	132790	12.0
UNIVERSITY							
University of Houston	427425	354103	330356	239449	260404	287726	-32.7
Texas Tech University	333628	322594	311058	168000	161306	164097	-50.8
Texas Woman's Univ.	306461	300056	297981	262400	263455	247273	-19.3
Southwest Texas State Univ.	294853	261274	278740	274088	296196	270007	-8.4
Midwestern State Univ.	259904	163820	188370	129700	114246	119984	-53.8
Angelo State University	240881	217126	231895	113965	111159	108714	-54.9
Stephen F. Austin State Univ.	201640	180077	198194	174398	159236	155124	-23.1
Prairie View A&M University	187770	188722	184640	243744	229204	267337	42.4
West Texas State Univ.	162195	157928	171209	129450	128616	122732	-24.3
North Texas State University	161956	151483	146753	137076	131371	131335	-18.9
Pan American University	156758	129841	136746	182640	201482	205268	30.9
Sam Houston State University	151163	115815	83679	115383	99835	99123	-34.4
U.T. El Paso	137329	115317	116091	125953	120305	134653	-1.9
U.T. Arlington	112312	88371	119529	216787	234396	215050	91.5
Texas A&I University	95111	87524	87450	89809	86907	83680	-12.0
CO-GENERATING UNIVERSITIES							
Texas A&M University	479191	478690	441424	430417	422386	380761	-20.5
U.T. Austin	378402	366661	393899	430385	460588	473210	25.1

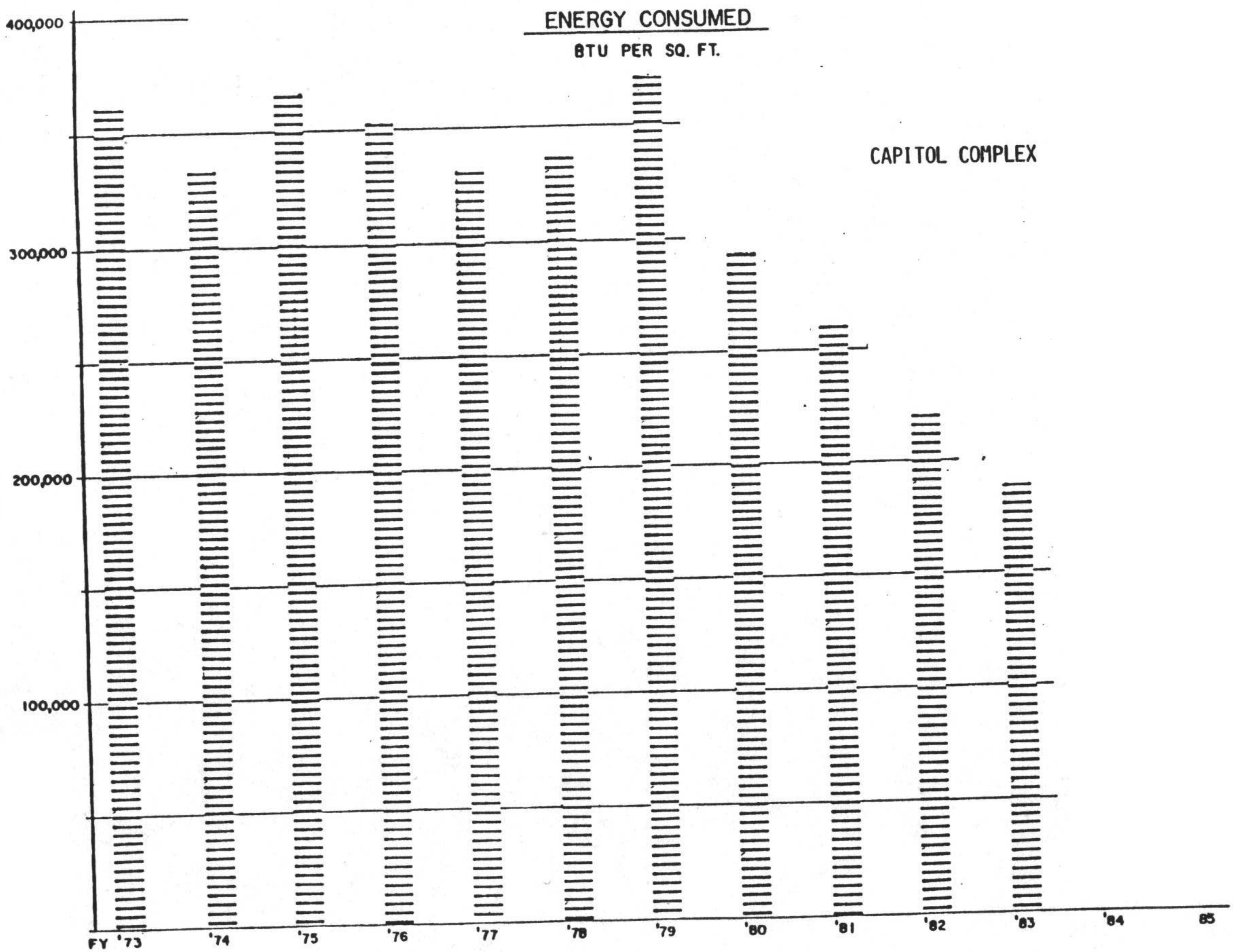
have correct data. Several important observations can be made from Table 4.

1. 22 of the 23 institutions listed responded to the energy crisis between 1973 and 1974 by reducing energy. The short-term conservation measures, i.e., reducing lighting, turning off lights, changing thermostats, etc. were indeed effective. However, in 15 of the 23 agencies, energy consumption increased again in 1975, when our "energy crisis" was thought to be over. Only a few agencies had, however, 1975 energy consumption higher than the 1973 levels. The conservation programs definitely worked in 1974.
2. Most agencies have cut energy consumption from the 1973 level. This is due, in part, to agency conservation programs, and, hopefully, in part due to the addition of newer, more energy-efficient buildings.
3. The trends at several universities are in the wrong direction. UT-Arlington, Prairie View, and Pan American all have increased energy usage in the past ten years. The trend at UT-Arlington is especially alarming. They have added many new buildings in the past 10 years, and if the energy data are reported correctly, it indicates that the newer buildings are consuming much more energy than the older ones.

In order to establish "target" energy reductions among the agencies, a proper base must be selected. To do this correctly, historical data are needed. The extreme example of this is Angelo State University. Looking only at the 1981-83 data, one would conclude that some mild energy management practices might be in place, since there was a slight decrease in energy consumption from 1981-83. Looking at their data from 1973-75, however, one gets a completely different picture. Their energy consumption has literally been cut in half over a 10-year period. The same holds true for Midwestern State University. The authors recommend that goals be set by the governor's budget office for energy reductions in the state agencies, but the goals should be established on a 1973-75 baseline. <u>Those agencies who have already implemented conservation programs should not be penalized by their inability to provide substantial decreases in their current energy consumption.</u>

Figure 1 is another graphic example of a conservation program. The EUI's in the capitol complex averaged 350,000 Btu/sf/yr from 1973-1979. The conservation program has resulted in a decrease of nearly 175,000 Btu/sf/yr from 1979 to 1983. (The EUI data in Figure 1 are based on Conditioned square footage

Figure 1 - Energy Consumption in the Capitol Complex, 1973-83



as opposed to gross square footage.)

Climatic Variations Affecting State Agency Energy Use

The data in Tables 1-4 have not been corrected for weather variations, and it is true that the climate will affect the energy consumption of most buildings. Appendix A contains a discussion of weather and its affect on the Texas agencies. The methods chosen were to use heating and cooling degree days (HDD and CDD) in the analysis. Both these methods use 65 F as the base and assume that cooling is needed above 65 F and heating below 65 F. Monthly heating and cooling degree day data are published by the National Weather Service for 18 cities within Texas. Although the details are included in the Appendix, the findings will be summarized here. First analyzing agency data for FY'81 and FY'82 using the HDD and CDD methods, showed only slight differences from one year to the next. EUI's generally changed ±2% based on climatic differences. Hence only 1 or 2% changes in agency energy consumption from year to year could normally be attributed to the weather at a given location. Second, there are significant differences in energy consumption depending on the location in the state. As noted in the Appendix, North Texas State University and the Austin State Hospital were "relocated" in Amarillo, Austin, Houston, Brownsville, Midland-Odessa, El Paso, and Dallas/Ft. Worth, and the EUI's were determined for each location. There was a significant difference in the EUI's, with Amarillo being the highest and Brownsville the lowest. There was very little difference between Austin and Houston, and those institutions along the same latititude from Dallas/Ft. Worth to El Paso geneally had about the same EUI. As much as a 50% variation does exist from the highest to the lowest within the state, as noted in Appendix A. Using the climatic comparisons in Appendix A, agency energy consumption can be generally compared for the various locations within the state.

Thermal Energy Cooperative (TECO)

Although not a state agency, the Thermal Energy Cooperative (TECO) does have a big influence on energy costs to the state of Texas. TECO is located in Houston, TX near the medical complex and serves 13 customers in that area. The state agencies served are: UT-School of Medicine; UT-School of Public Health; UT-Freeman Building; Texas Woman's University; University of Houston Pharmacy;

M.D. Anderson Hospital; and UT-Speech and Hearing Institute. Both steam and chilled water are supplied from the TECO central plant.

All 13 thermal energy customers are on the TECO board and share in the decisions of the cooperative. Prior to the formation of TECO, the plant was run by Houston Natural Gas. The plant equipment was apparently getting old, and plant operation and maintenance costs were being passed on to the thermal customers. There was an option in the contract, however, that the plant could be purchased by the thermal customers. The option was exercised, and the cooperative was formed in the late 1970's.* Since that time, TECO has been continually upgrading the plant, replacing the less efficient steam turbine drives with electric motor drives. In addition, TECO has installed a 6 MW gas-driven, diesel engine to generate their base-load electrical power. Waste heat is recovered from the engine and exhaust making it a cogeneration facility. At the May meeting with TECO, they indicated that the cost of site-generated electricity was between 4.5 and 5¢/kwh, considering credit for the thermal energy.

Charges to the customers are based on fixed costs, demand, and energy costs. Any excess "profits" by the cooperative are distributed back to the "owners" at the end of the year. These savings should be reflected in a return to the state of that portion of the agency's utilities funding. The TECO management philosophy over the past several years has been to retire the capital expenditures for plant improvements as quickly as possible. As a result, the thermal rates are somewhat higher than energy rates charged by thermal suppliers at some of the other agencies. This philosophy and the cogeneration should result, however, in a levelling of energy costs for the state agencies served by TECO. After viewing the plant and discussing the TECO operataion and rate structure, it is the opinion of the authors that TECO is moving in the right direction. Replacing the steam turbine drives and installing a cogeneration system could conceivably even reduce utility rates in the near future, particularly if gas prices stabilize, as predicted. The facility is using less gas now than in the 1979 era, and is producing most of their electrical needs at a rate comparable to what HL&P can sell it to them. They will be much less dependent on electrical power rate increases now than in the past.

Decreases in the utilities costs for the state agencies served by TECO are

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*Meeting between representatives of TECO, UT-Health Sciences Center, UT Facilities Group, and Energy Management Group at A&M, May 1984.

possible, but the principal savings will have to come from reduced energy consumption at the agencies through conservation. Because the thermal energy supplied by TECO is more costly per Btu, conservation measures taken by the agencies served by TECO will be more cost effective and will result in much faster paybacks.

Detailed Monthly Energy Consumption

Appendix C contains monthly plots of natural gas and electricity consumption at the state agencies as well as supporting data used in compiling the agency EUI's and ECI's. Agency areas, annual energy consumption, and FY'83 fuel and electricity prices are included in Appendix B.

Summary

There is a great potential for energy and cost reductions within the state agencies; however, there are problems associated with the conservation effort. Some of them are:

1. The current state practice of funding utility/energy budgets is a detriment to agency energy conservation. Utility/energy costs are funded separately. If an agency exceeds its allotted energy bill, it asks for a supplemental appropriation. If the agency does not use the utility funds, the money is returned to the state at the end of the FY. Agencies are reluctant to spend funds allocated for capital improvements for conservation, because the dollars saved do not benefit the agency directly. Unspent utility dollars go back to the state.
2. There are few qualified technical personnel at the agencies to administer conservation programs. At the governor's request, all state agencies were to designate agency energy managers this year, but, in most cases, these were budget/financial people. In addition, the title was simply added to the person's other duties. The capitol complex conservation program is an example of what can be done by a trained energy manager. Literally millions of dollars have been saved in the past six years in the capitol complex alone. An energy manager at a major agency could potentially save many times his annual salary in conserved energy.
3. There is no central state agency responsible for energy conservation within

the state. Energy control is fragmented at best, but in reality, there is no state agency which can be held accountable for the state agency energy consumption.

4. Energy conservation opportunities do exist at virtually all the state agencies. There does not appear to be significant reductions in energy for many agencies in the past several years. This may indicate that the newer buildings being built are not as energy efficient as they should be.

Recommendations

1. There is a need for a comprehensive state energy management program. Some of the agencies are concerned that the current effort will be as short lived and unorganized as some have been in the past. A master program should be developed that will set overall objectives, goals, etc. as well as implementation schedules and strategies for both the short run (1 to 3 years) and the long run (3 to 10 years). An evaluation should be done at some point in the future to assess the success or failure of the program. This program should provide whatever direction is necessary for the energy conservation efforts. Without a comprehensive energy management program, the current effort will probably have a minimal impact on energy use and energy expenditures in the long run. Perhaps something can be learned from other states such as Minnesota or California who have had fairly aggressive conservation programs.
2. Set up a state office (or use an existing one) that would have the expertise to manage this project. This office must know what its mission is and be able to provide the resources (both financial and otherwise) to make the conservation program a success. There is currently little coordination of energy resources among the state agencies. This office could cut through red tape that might prevent agencies from cooperating on a joint cogeneration venture or conservation effort. It could also serve as the focal point for energy data compilation and problem solving. The Governor's Office would have to determine the appropriate agency to locate this office.
3. A baseline agency energy consumption should be established based on the 1973-75 agency energy use. Definite conservation goals can then be established for the state agencies.
4. Create economic incentives for agencies to conserve energy. The way

current appropriations are handled for most state agencies is to give them a pot of money for their physical plants. It is typically bumped up each year, thus encouraging them to not do anything out of the ordinary in conserving energy. Some incentives could be made available for the agencies to save energy. Say, if the agency reduced consumption 10%, they would be able to take some of that savings and reinvest into more conservation programs, hire staff, or shift the money to another part of the agency that needed improvements. A 50-50 split of the conserved energy dollars should be sufficient to encourage agencies to conserve.

5. Hire qualified energy managers at each large agency. It is not unusual for the designated "energy manager" to be a person who has many other responsibilities and who may have no direct training in the field. Either the state is going to have to provide some direct support from a central office to these agencies or provide enough financial support to the agency to create an energy manager position. Probably a resident energy manager is preferable since that person would be able to become intimately familiar with the physical facility and how it uses energy. That person would also be able to insure that operational changes instituted at a given point in time remained in force.
6. Promote information transfer between agencies. In discussions with several agencies, it is evident that some have tried various "energy conserving" devices or strategies. Some have been successes, while others have been failures. Perhaps an annual conference could be arranged for the energy managers in each of the agencies to gather and discuss ideas, problems, etc. It is possible that the agencies that have had successful programs will be able to help those who have not had very successful programs. Perhaps some seminars or short courses could also be used as part of the conference to equip the energy managers to do the job they are supposed to be doing. This conference could also help the Governor's Office or PUC keep up-to-date with direct feedback on what is or is not going on in each agency.

CHAPTER 2

MINIMUM EFFICIENCY STANDARDS FOR NEWLY CONSTRUCTED STATE BUILDINGS

One option for reducing the growth of future energy consumption and expenditures is through the use of energy standards for all new construction. This chapter discusses the standard that is currently in place, and the potential savings that could result from a new strict standard.

Background

Generally, there are two approaches to energy standards. These are the performance and prescriptive approaches. A performance standard is one which dictates the maximum amount of energy a building can use. This is usually expressed on a Btu per square foot or Btu per square foot per degree day basis. In a performance standard, the building designers have an opportunity to design the building with whatever features they deem appropriate just as long as the building's estimated energy use is less than what the standard requires. A prescriptive standard "prescribes" what conservation measures are mandatory in a building: amount of insulation, window glazing, etc. The advantage of the prescriptive standard is that the required measures can be monitored as the building is being completed. It is also easier for some contractors (those without the tools to estimate performance) to comply with this type of standard. The primary disadvantage of the prescriptive approach is that it usually focuses on conventional conservation measures and is insensitive to orientation of the building, innovative designs, passive solar cooling and heating, etc.

Existing Standards

In 1976, the state legislature passed a bill requiring the State Building Commission to develop energy standards on all newly constructed state buildings [2] (see Appendix D). The purpose of the bill was to:

"...provide for the development of improved design, lighting, insulation, and architectural standards to promote efficient energy use in state buildings of state-supported institutions of higher education...to achieve the minimum lifetime cost for all new state buildings...measured by the combined construction and operating costs..." Section 2, Senate Bill No. 516.

The standards were to be developed and promulgated by the State Building Commission (SBC). The SBC was to:

"...Adopt and publish energy conservation design standards that all new state buildings, including buildings of state-supported institutions of higher education, [were] required to meet." Section 3, Senate Bill No. 516. The SBC was to also provide technical assistance and advice to any other state agency, commission, or institution on the implementation of the standards [2]. Part of this assistance was the development of manuals that provided guidelines, charts, forms, data, etc. necessary for a contractor to meet the standard for a new building. These manuals were to be updated periodically as "significant new energy conservation information" became available.

As a result of the legislation, the SBC published the first energy standards for state buildings in Texas in the spring of 1977 [3,4,5]. The standards were a combination of performance and prescriptive approaches. There were performance indices for the shell of the structure and some prescriptive components such as not allowing electric resistance heating, minimum coefficients of performance for air conditioners, etc.

Probably the single most outstanding feature of the existing standards is they failed to accomplish the purpose for which they were intended. Their failure can be traced to three primary causes: (1) they were not easy to understand, (2) they were never really enforced, and (3) they were not very tough.

The Texas standards were not easy to follow and understand. It utilized terms such as the Envelope Energy Indices (EEI) that were unfamiliar to design professionals who were estimating energy use in buildings. It really is not clear from the manual what relationship, if any, the EEI has to the total design energy use in the buildings. The manual for apartments and non-residential buildings was over 200 pages long and not easy to follow.

The second contributing factor to the failure of the existing standards was the lack of enforcement. The SBC, which had the power to enforce the standard, apparently never did. When the SBC was absorbed into the Facilities Construction and Space Maintenance Division of the State Purchasing and General Services Commission (SPGSC), its authority to enforce the standards was also transferred. However, SPGSC did no enforcing of the standards outside of their own agency [6]. Thus, the state was left with an energy code with no agency serving as the watchdog to see that its requirements were met.

The last contributing factor to the failure of the standards was their leniency. From conversations with personnel in SPGSC who have compared the standard to some of the new buildings in the Capitol Complex, the new buildings have no difficulty meeting the standard because the standards are not very stringent. This appears to be consistent with observations during the last few years. Table 5 shows energy use and new floorspace added from 1975 to 1983 at three universities. Since total energy use either went up or remained constant at these schools, it can probably be deduced that the new floorspace added during this time was either at the same or greater energy intensity as the existing floorspace of the schools.

Table 5 - Energy consumption indices for three state universities from 1975 to 1983 Consumption (Btu/sf/yr)

AGENCY	1975	1981	1982	1983
Southwest Texas State	279,000	274,000	296,000	270,000
Univ. of Texas-Austin	394,000	430,000	461,000	473,000
Univ. of Texas-Arlington	120,000	217,000	234,000	215,000

What are the financial consequences of the failure of the standards? It is impossible to know exactly, but it is possible to make an estimate for a particular institution. Consider the three institutions shown in Table 5. It is not unreasonable to expect a quality design office/classroom building to use 100,000 Btu/sf/yr in central Texas. Buildings meeting the ASHRAE 90-75 design standards (which have been in existence since 1975) that the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) should come in well below this value [7,8]. If all new construction had been built at this level then these buildings would probably be costing about $800,000 dollars less to operate at Southwest Texas State and U.T. Arlington (see Table 6). The savings at U.T. Austin would be about 1.7 million dollars per year. For these three institutions alone, the state has lost annual savings of over 3.3 million dollars. Or, to put it another way, the state is having to spend over 3.3 million more dollars per year in fuel costs than it would have if the buildings had been designed with energy efficiency in mind, and that is just at these three universities!

Table 6 Potential energy and dollar savings from a 100,000 Btu/sf/yr standard

AGENCY	FLOORSPACE ADDED (SF)	ENERGY SAVINGS (BTU/SF/YR)	DOLLAR* SAVINGS ($)
Southwest Texas State	706,000	170,000	860,000
U.T.-Austin	1,531,000	250,000**	1,761,000
U.T.-Arlington	934,000	115,000	823,000

*Assumes 1983 prices
**Includes Power Plant Conversion Efficiency of 60%

Another consequence of not enforcing the standards is that the state does not know precisely how much energy these new buildings are consuming. A major provision of the standard was the metering and collection of energy use data on these buildings. The standards state [3]:

"All new buildings and, wherever practicable, existing State buildings, shall be separately metered for the purpose of monitoring their actual energy usage...All new buildings built by State agencies shall be separately metered to record all forms of energy input to buildings for this purpose." (p. 3, ref. 3). Many of the new buildings are not separately metered as specified in the standard. The metering was supposed to provide the state with a continuous record of the energy use of these buildings to insure that they performed as expected. Each agency was required to fill out an energy use form for each of these buildings and send it to the SBC. The SBC (and later the SPGSC) was supposed to compile the data "according to building type, location, operational characteristics, etc., for the purpose of establishing historical building energy usage consumption indices" [3]. From conversations with personnel at the SPGSC, this was never done [6].

Not having this energy use data will have potentially severe consequences in future years. Without metered data on these buildings it is impossible to assess the economics or cost effectiveness of implementing conservation strategies on the buildings because the annual energy costs for it are not known. Not having the data means that it will also be impossible to know if conservation strategies either worked or are continuing to work. The energy usage data is the minimum acceptable data needed for a competent energy manager to do his job.

Future Standards

Each new building that the state constructs will use energy for many decades to come. If it is built to tight energy efficiency standards, then the savings will be cumulative over its entire life. Failure to build the building to strict standards will mean that the state will be paying potentially large sums of money that could have been spent in other, more critical, areas. To understand the potential savings to the state from a strict standard, consider the following example. Between 1985 and 2005, the state's population is expected to grow at an annual rate of about 2.0%. If the growth in state employees parallels the population growth in the state as it did in the 1970s and 1980s, then the number of state employees will grow at about 2.3% per year. Floor space will grow at a smaller rate than the number of employees. For this analysis it is assumed to grow at 1.2% per year.

Now consider two possible futures. The first is one in which the state does not require any standards on new buildings. For this case it will be assumed that the new buildings will use 175,000 Btu/sf/yr (This is probably close to current construction practice at the agencies). The second possible future is one where the state has a strict standard in which all new buildings have to be designed at an average of 75,000 Btu/sf/yr. As indicated in reference 8, this should be a reasonable design goal for many buildings. At a 1.2% annual growth rate, the amount of floorspace in the stock in 2005 that had been added since 1985 will be 35.5 million square feet. The annual energy savings in 2005 resulting from the implementation of standards in 1985 will be 3.55 trillion Btus. If an average fuel cost of $7.50 per million Btus were used (this is close to 1983 average price for all fuels over all the agencies), the annual fuel cost savings would be 27 million dollars. If a conservative fuel escalation rate of 5% per year were included in the fuel price, the annual savings in 2005 would be 70.6 million dollars.

Thus, there is a large potential savings in the future in implementing standards. The alternative is much higher fuel bills for the state and a waste of much needed dollars from the state treasury.

The state should seriously consider a tough energy standard on all new state buildings that will be implemented as soon as possible. It should be a performance rather than a prescriptive standard. The better design professionals have the tools and expertise necessary to design to a performance standard. A possible choice for the new standard could be the latest version of the ASHRAE 90 standards. The state should not try to come up with a standard from "scratch" as was done previously. It would only cause more confusion and would probably not be any better than the ASHRAE standard.

The new standard should be one that is strictly enforced. This would require that the state legislature appropriate the necessary funds so that the state agency delegated to enforce it could provide adequate policing of it. Without this, there will be no "teeth" in the legislation.

This standard should also have a similar provision on metering that the previous standard had. That is, all new buildings should be separately metered for all fuels. There should also be a central file where all the energy use data is maintained. This will provide necessary data to the agencies and planners on how well the buildings are performing.

An added provision should be the mandatory metering of all fuels in the large existing buildings. A reasonable cutoff may be buildings with square footages over 200,000 square feet. Table 7 shows the number of buildings over 200,000 square feet in a selected number of agencies. These buildings typically use from $250,000 to $500,000 per year in fuel costs. This would limit, to a reasonable number, the buildings to be retrofited with meters, and would insure that the biggest energy users are monitored. Metering these buildings would also provide the agencies with a sampling of how effective their conservation measures are working.

Table 7 - Number of buildings over 200,000 square feet at selected agencies and institutions

AGENCY	NUMBER OF BUILDINGS
UT-Austin	19
TAMU	7
UH-Univ. Park	7
Capitol Complex	3
UT-Arlington	3
SWTSU	1
NTSU	1

Summary

Texas is at a crossroads with respect to standards for new buildings. The mistakes of the past are evident in the failure of the previous standards. The primary lessons which should be applied to the new standards are: write them clearly, enforce them, and make them strict. The state must act quickly and decisively in the next year to implement strict energy standards on its new buildings. Failure to do so will guarantee a drain on the state treasury of millions of dollars annually for excessive fuel bills on the buildings that will be built in future years.

RECOMMENDATIONS

1. The state should institute new energy standards on all new state buildings. These standards should be performance oriented. These standards should also be strict compared to the existing standards. They should also be enforced. Money should be made available to the enforcing agency to adequately insure that the standards are kept.
2. All new buildings should be required to have their energy consumption metered. This will provide the agency energy manager and the state with direct information on the performance of newly constructed buildings.
3. All existing buildings over 200,000 square feet should be metered. These are the buildings that use large quantities of energy and are costly to operate. Metering these buildings will allow better evaluation of the cost effectiveness of any retrofit conservation measures.

Chapter 3

NATURAL GAS IN TEXAS STATE AGENCIES

This chapter discusses the consumption and the use of gas produced on state owned lands. It is divided into two sections: Gas Consumption and State Gas Utilization. Data relevant to each area are presented and critical issues discussed.

Gas Consumption

The combined state agencies consumed approximately 19 million Mcf of natural gas in 1983, which was only slightly higher than the 18.5 million Mcf consumed in 1973 [1]. The fuel bill for all this gas usage was approximately $90 million which is three to four times the bill in 1973. If fuel prices continue to rise at 10% per year, then in 1993, the annual gas bill for the state agencies will be over 225 million dollars.

Most of the gas consumption is concentrated in a few agencies and institutions. Table 8 shows 1983 gas usage for the top 12 users. These 12 users accounted for almost 80% of gas usage and fuel costs in state agencies. Even more prominent is the consumption of gas at the top two agencies: the University of Texas at Austin and Texas A&M University. These two universities account for almost half of all gas usage and costs. Both institutions have large physical facilities and are using gas to cogenerate steam, chilled water, and electricity. Having such large concentrations of gas usage in a few agencies may prove to be beneficial for any efforts at conservation, gas price negotiations, or other policies. For instance, the savings in gas associated with a 10% reduction in gas usage at UT Austin and Texas A&M would equal the total 1983 gas usage of North Texas State University and the Capitol Complex. Thus, the heavy concentration allows the state to make potentially large reductions in gas usage and bills by focusing on a small number of agencies or institutions.

Table 8 - Top Twelve Gas Consumers of Texas Agencies and Institutions

AGENCY	1983 CONSUMPTION (10^3 MCF/YR)	1983 PRICE ($/MCF)	1983 BILL (10^6 $)
UT-Austin	5524	4.60	25.40
Texas A&M	4054	4.48	18.14
TECO*	1093	4.75	5.19
Texas Tech (Physical Plant & Campus)	1082	3.81	4.11
UH (Univ. Park)	969	5.61	5.43
SWTSU	615	5.27	3.24
TWU-Denton	387	4.22	1.63
UT-Arlington	348	4.16	1.45
TDC Coffield	305	5.22	1.59
Capitol Complex	267	5.13	1.37
TDC Jester, Central	263	4.66	1.22
NTSU	227	5.37	1.22

*Thermal Energy Cooperative which supplies thermal energy to several state agencies in Houston medical center complex.

Another observation that can be made from the average gas price data (see Table 17) is that there are some large differences in the average prices for some agencies in the same location. For instance, North Texas State University (NTSU), Texas Woman's University (TWU), and the Denton State School are all located in Denton and served by the same gas company (Lone Star). However, TWU's average gas price in 1983 was $4.22 compared to $5.27 for NTSU and $5.41 for the Denton State School. There should be no significant differences between the NTSU and TWU rates since both use comparable amounts of gas. NTSU was on a non-interruptable rate schedule in 1983 which accounted for its higher price. Each agency should examine its rate schedule to see that it is on the lowest possible one to satisfy its requirements. For some institutions such as hospitals, it may not be feasible to go on an interruptable schedule, but they are probably the exception. It is not possible to determine at this time how many agencies could get into a lower rate class, but each agency should be required to examine its schedule annually.

Utilization of State-Owned Gas

One potential option to reducing gas bills in state agencies is the utilization of gas that is on land the state owns. Private companies sign leases to do the drilling and exploration of the land. If gas is found, then the state collects a royalty off each cubic foot of gas brought out of the ground. This royalty percentage varies from a few tenths of a percent to over 75 percent of the selling price of the gas depending on the age and location of the lease. The state also has the option of receiving the royalty payment in gas rather than money. This option is referred to as "in-kind" production. That is, the state takes its share of the gas as payment in-kind for its royalty share. Typically, the state must give the gas operator 60 days notice that it is going to take the in-kind gas rather than monetary payment for its royalty.

The State of Texas holds lands that are currently producing large quantities of gas. In 1983, the gas produced on state-owned property totaled over 200 million Mcf. Of this total, almost 49 million Mcf were in-kind gas [9]. Most of this gas is produced on wells that are offshore. The production from gas wells range from zero to several million Mcf per year. The wells that are not producing are generally wells that currently have no market for the gas that they could produce. Table 9 shows the production from the three largest producing leases.

Table 9 - Gas Production from three largest leases on state owned lands. Source: GLO [9]

Lease	County	1983 Production (MCF)	In-Kind Share (MCF)
59099	Galveston	8,720,621	1,453,439
69137	Matagorda	14,666,540	2,444,428
71369	Kleberg	15,310,682	3,062,136

There are two possible approaches to using the gas that the state produces. The first approach is to have a particular institution or agency attempt to utilize the gas produced on its own land. The second approach is for the state to act as broker for the in-kind gas that is produced on its land and sell it to an agency at the best price. The first approach leaves the primary responsibility to the individual agencies, while the latter requires the General Land Office to help the other agencies negotiate for transport of state gas to their facility. Both approaches have been considered in the past and are discussed below.

Agencies Use of Their Own In-Kind Gas

An example of the first approach can be seen in the rider attached to the 1983 Appropriation Bill that required state agencies to study the possibility of using gas produced on their own lands. Specifically it said:

> "Before expending any funds appropriated by this act for the acquisition of oil, gas, coal, lignite or other natural resources used in the production of energy, any agency or institution...shall use, to the greatest extent practical, resources produced from land owned by the institution or agency to meet the energy requirements of the particular institution or agency." Section 73, 1983 Appropriations Bill, State of Texas.

The emphasis of the bill was on the particular agency attempting to use gas (or oil) produced on their own lands. In order to make a significant dent in a particular agency's bill, the in-kind gas produced on their land must be of significant quantities and be cheap compared to what they are paying the gas utility. Another desirable feature would be that the gas produced be comparable to the consumption of the agency and that the consumption be concentrated so the agency would not have to pay large transportation fees for the gas. Unfortunately, there are not many agencies with gas-producing land. Some of the ones that do have gas-producing lands have only small quantities of gas (see Table 10). Most of these agencies do not have a good match between production and consumption (see Highway Department for example). Even though agencies like Parks and Wildlife and Mental Health and Mental Retardation have production that is larger than their needs, their facilities are scattered throughout the state and their consumption is not concentrated.

Table 10 In Kind Production within State Agencies
Source: GLO [9]

AGENCY	1983 CONSUMPTION	1983 IN-KIND
Highway Dept.	310	3
Parks and Wildlife Dept.	5	263
Texas A&M	4053	281
MHMR	2	5
TDC	911	456

The one state agency that appears to meet all of the above mentioned conditions is the Texas Department of Corrections (TDC). Table 11 shows the 1983 consumption and production at the 5 TDC facilities. At the Clemens and Jester facilities, there are good matches between in-kind production and consumption. At the Clemens facility the price that the state is receiving from the sale of gas is approximately $4.00 per Mcf less than what it is paying for the gas it consumes. Table 12 gives a summary of the potential annual dollar savings (based on 1983 prices) that the TDC could save at each facility if it could utilize its own in-kind gas. The savings at the Clemens and Jester facilities are over one half million dollars a year.

Table 11 - 1983 Gas Consumption and Production in TDC Facilities
Source: GLO [9]

TDC UNIT	GAS CONSUMPTION MCF	AVERAGE PRICE PAID ($/MCF)	TOTAL PRODUCTION (MCF)	IN-KIND GAS (MCF)	AVERAGE PRICE ($/MCF)
Clemens	79926	4.82	453493	75582	$0.78
Coffield	305259	5.22	699722	43733	$3.34
Darrington	87217	4.80	40531	10933	$3.20
Jester	262558	4.66	1481923	296385	$3.45
Ramsey	176528	4.65	206851	28964	$0.51

Table 12 - Potential Dollar Savings on TDC Lands with
TDC In-Kind Gas

TDC UNIT	IN-KIND SAVINGS ($/MCF)	IN-KIND SAVINGS ($/YR)
Clemens	4.04	305351
Coffield	1.88	82218
Darrington	1.60	17493
Jester	1.21	262557
Ramsey	4.14	119911

There are two possible ways the TDC could utilize their in-kind gas. These are: (1) tap the wellhead directly and extract the in-kind share necessary to operate the particular facility, and (2) negotiate with the pipeline companies to deliver the in-kind gas at the well head price plus fees for transportation, odorization, etc.

At first glance, it would appear that the first option is an attractive one. It potentially provides complete autonomy from the gas company and the inevitable gas price increases. However, the disadvantages seem to outweigh the advantages. For example, it would require construction of a gas distribution system as well as the maintenance and repair of it. It is also questionable whether the TDC has the expertise to operate a gas odorization-pressurization system. TDC also has to worry about the possible liability exposure for personal injuries from a natural gas accident [10]. Probably the biggest problem with this approach is that is is impossible to predict precisely how long a well will produce at the given production volume. It is quite possible that the TDC would get the facilities in place in time to see the well quit producing.

Texas A&M has also considered extracting its share of the gas produced on some of the land it owns near its campus and piping it to its power plant. However, it was not economical to undertake such a venture [11].

The second way for an agency to utilize its own in-kind gas is more desirable because the TDC would not have to go into the gas pipeline and production business. They would renegotiate the current gas contract so that the in-kind gas would be delivered to them at the wellhead price plus appropriate fees for transportation, odorization, profit, etc. The TDC is currently examining this option [12]. It is also possible that the TDC could purchase the total production from several wells. This is particularly attractive to the well operator since it would provide him with a guaranteed source for the gas being produced from the wells. With a guaranteed buyer, the gas well would never be shut-in and would produce continuous royalties. The problems associated with getting the pipeline companies to cooperate with this type arrangement are discussed in the next section.

From discussions with officials at several agencies, it is apparent that most of them still think of using in-kind gas primarily in terms of the first option. Because of the disadvantages of this approach it is usually dismissed quickly. It is apparent that the General Land Office is going to have to educate these officials that there are other options open to them, particularly the purchasing of in-kind state gas as discussed in the next section.

Agencies' Use of State's In-Kind Gas

Another possible approach to utilizing state owned in-kind gas is for the State to make available to individual agencies the in-kind gas that is produced on any state-owned land. Most of this gas is produced at offshore wells that are leased on state property. The total in-kind production in 1983 was about two and one half times larger than total gas consumption in all the agencies, so this has a great potential for saving money. Because it would guarantee a market for some of the gas produced on state-owned lands, it would also have the added benefit of producing a more stable and possibly larger flow of funds to the Permanent School Fund.

Currently, this is the approach being taken by the General Land Office. They have a voluntary program in place in which those entities (state agencies, cities, etc.) interested in buying gas from the State may approach the Commissioner on an individual basis. Each entity provides the Land Office with details on their current usage, costs, and supplier. The Land Office then provides information of the volumes of gas available and at what price. The arrangements for transportation are made between the agency or city and their supplier. To date, only one contract for the sale of state gas has been made. That contract is with the City of San Antonio. However, the cities of Corpus Christi and Castorville, plus Southwest Texas State University have had their gas prices lowered by the gas companies serving them as a result of the state making an offer of cheaper gas to them. See Table 13.

Table 13 Average gas price for three cities and one agency resulting from GLO negotiations.

AGENCY	GAS COMPANY	PRICE ($/MCF) PRICE
San Antonio	Valero	3.20
SWTSU	Entex	3.55
Corpus Christi	Valero	3.40
Castorville	Valero	3.50

The potential savings to the state for selling its gas to only a few of its agencies are large. For instance, if the state could sell its gas to only the University of Texas and Texas A&M University at a price of $3.50 per Mcf, there would be a cost savings to the state of about 10 Million dollars based on 1983 gas prices and consumption levels at these two schools (see Table 14). This probably represents about half the dollar savings possible to the state throughout all other agencies. Thus, it appears that the top priority for negotiating with in-kind gas should be at these two facilities. They offer the largest potential individual savings to the state. The other large users shown in Table 14 should then be the next highest priority.

Table 14 - Potential Annual Savings in Gas Costs for a $1/MCF Reduction in Fuel Price

AGENCY	ANNUAL SAVINGS
UT Austin	$5,524,000
Texas A&M	4,053,000
UH Univ. Park	969,000
TECO	820,000

Less than a handfull of agencies and institutions have responded to the GLO's voluntary program. Because of the large potential savings associated with this program, it should be made mandatory. The GLO should also be the agency that does all the bargaining with the particular pipeline companies. This will insure that the pipeline companies only have to talk to one agency and it should put the state in a better bargaining position since GLO personnel are generally more experienced than agency personnel in negotiating with officials from gas companies. With a mandatory program, the GLO would probably also have to increase staff to handle adequately the increased cases.

One of the major obstacles to the state selling gas to entities such as cities or agencies has been the unwillingness of gas pipeline companies to transport the gas. If the pipeline company refuses transport, then it is not possible for the state to get the gas delivered to the buyer. Several potential contracts have already fallen through because pipeline companies have refused transport. These are shown in Table 15.

Table 15 - Potential gas sales where gas pipeline companies have refused transport. Source: GLO [9]

Potential Buyer	Pipeline Company
City of Gruver	Panhandle Eastern
North Texas State Univ.	Lone Star
Sam Houston State Univ.	Entex

Currently, there is no requirement that pipeline companies have to deliver the gas that an individual, company, or state has. It is entirely up to the willingness of the pipeline company to transport the gas. This poses severe restrictions on the possibility of selling the in-kind gas to state agencies. Table 16 shows the twelve largest users of gas among the state agencies and the gas company that serves their facilities. Five of the facilities are served by Lone Star while four are served by Entex. Since both of these companies have either refused to talk to the state or refused transport in the past, it is unlikely that they will voluntarily change in the future. This leaves only three agencies out of the top twelve users being served by companies that have not been approached about transporting state gas. If both Southern Union and Energas refuse, then none of these twelve agencies could receive the benefit of the cheaper state gas.

Table 16 - Gas Companies Serving Top Users

AGENCY	GAS COMPANY
U.T.-Austin	Southern Union
Texas A&M	Lone Star
TECO	Entex
Texas Tech	Energas
U.H.-Univ. Park	Entex
SWTSU	Entex
TWU-Denton	Lone Star
U.T.-Arlington	Lone Star
TDC Coffield	Lone Star
Capitol Complex	Southern Union
TDC Jester, Central	Entex
NTSU	Lone Star

There appear to be at least three possible options open to the state to get the pipeline companies to transport state gas to the agencies. The first option is to have the General Land Office refuse right-of-ways on state-owned land for those pipeline companies refusing to cooperate. This could potentially force the hand of those companies who are currently refusing transport. Another option would be to pass legislation requiring the pipeline companies to transport gas upon request. There are currently bills pending in the U.S. Congress to do this, but it is uncertain how strongly worded these bills will be or when these bills will be passed. It may be feasible also to pass a bill in the Texas legislature if the state were unwilling to wait on the U.S. Congress. The third option is to wait on the outcome of a lawsuit between the State of Illinois and Panhandle Eastern Pipeline which charges Panhandle Eastern with violation of anti-trust laws because it refused to transport gas to the University of Illinois. A decision on that case favorable toward Illinois could put Texas in a very good position to get gas delivered to its agencies.

SUMMARY

Approximately 80% of the gas consumed by the state agencies is concentrated in the top twelve users. The two biggest users, Texas A&M University and the University of Texas at Austin account for almost 50% of all agencies' consumption and gas costs expenditures.

Even though the use of in-kind gas offers no savings in energy to the state, it does offer the potential for dollar savings through reduced gas prices. This option will only become a reality if the state and its agencies are able to negotiate transportation contracts with gas companies of gas from wells on state-owned lands. The state should make it mandatory for its agencies and institutions to work with the GLO to purchase and obtain transport of in-kind gas produced by the state. An obstacle to overcome is the refusal of some of the pipeline companies to transport state gas. Unless this situation is changed, the State of Texas will be robbed of an opportunity to reduce the gas bills in its agencies.

RECOMMENDATIONS

1. The state should require all agencies to work with the General Land Office in seeking the use of in-kind gas. Currently, this has been a voluntary program with a very limited response. The potential cost savings to the state for utilizing its own gas are too large to ignore. The two institutions that should be targeted first for this program are Texas A&M and U.T. Austin since they use about 50% of the gas consumed in all agencies.
2. The state should seek ways to obtain the cooperation of gas pipeline companies in the transportation of state gas to the agencies. Without the cooperation of the pipeline companies, the potential in cost reductions offered by state gas will never be realized. Lone Star, Entex, Southern Union, and Energas are the four pipeline companies serving the agencies with the largest gas use. If these companies will not willingly cooperate, then the state will either have to abandon the program or seek ways to force cooperation.

Chapter 4
COGENERATION OPPORTUNITIES

Introduction

Cogeneration is the simultaneous production of electrical and thermal energy, where the thermal energy is a byproduct of the electrical generation process. By cascading the energy extraction process, the heat energy comes essentially free of any associated fuel cost. While the conversion efficiency of fuel energy to electricity is typically about 35% for a conventional power plant, a cogeneration facility will recover an additional 35-45% in the form of waste heat. This heat energy is available to large power plants, but because of their typically remote locations and large quantities of heat generated, they have no recourse but to dump the heat to cooling towers or large bodies of water. It is this waste heat which the power plants cannot economically utilize that can pay for a cogeneration system. A small cogenerator cannot normally produce electricity cheaper than it can be bought from the large utility due to the economies of scale and favorable fuel rates provided to large utilities. The primary savings come from the fuel which is displaced in the normal operation of producing the low temperature heat.

While cogeneration can be defined quite simply, there are a host of ways in which the thermal and electrical energy can be produced. The main driver can range from a small automotive internal combustion engine all the way up to a large steam driven turbine. The waste heat can be taken from engine block cooling water, exhaust gas heat exchangers or condenser water. In order to simplify the following discussion, large steam cycle plants will not be considered since they would be applicable for only a few of the largest state agencies, and their cost and size would be nearly prohibitive in retrofit applications. The remainder of this discussion will involve engine driven systems, typically 15,000 kW in size and smaller. The prime movers under consideration will normally be further broken down into small scale and large scale groups based on engine performance and cost criteria.

There are a number of considerations which must be evaluated before deciding on a cogeneration installation. These factors cover both economics and the utilization of the system. Some of the primary considerations are:

1) INITIAL COST - If the facility will require capital up front, a payback period is normally calculated to gauge economic success. In the private sector,

a 3 year payback is often the norm, with some companies going to 4 years. An obvious reason for looking at cogeneration in state facilities is to reduce future budgets. Therefore, if the state does not realize a net savings within a fairly short time frame, legislators or agency officials will not consider such an investment worthwhile.

2) ELECTRICAL CONVERSION EFFICIENCY - Electricity typically costs anywhere from 3 to 7 times as much as natural gas on an energy basis. Therefore, it should be considered the prime energy source to be replaced by cogeneration. If the conversion of fuel (typically gas) to electricity is poor, then the cogeneration unit is little more than a gas burning heater, with no better conversion efficiency than a furnace or boiler. The economics of such systems will be shown to depend very heavily on the electrical conversion efficiency of the cogeneration system.

3) FUEL COSTS AND AVAILABILITY - Since cogeneration systems should be run continuously for good economics, it is only practical that a continuous supply of reasonably priced fuel be available for the life of the unit. Natural gas is the fuel of choice in Texas with its projected abundant supply for the next 10 to 15 years and its economical handling and clean combustion characteristics. Natural gas will be the type of fuel considered in this analysis since it requires no storage facilities, is clean burning, and is available to virtually all state agencies. It is normally quite a bit cheaper per Btu than other refined fuels.

4) RATIO OF THERMAL TO ELECTRICAL OUTPUT - The optimum use of cogeneration facilities is to have the system running at full load, generating its peak electrical output and having all its waste heat utilized. While agreements can be made with utilities for them to purchase excess electricity, the utility will typically pay a rate which is somewhat less than they charge the facility. Consequently, the economics are best when the higher priced purchased electricity is reduced, rather than producing excess power possibly at a loss. The system size must be such that virtually all the thermal energy can be used, as well as all the electricity generated. A building which uses large quantities of electricity but needs little heat energy is better off buying power from the local utility.

5) QUALITY OF RECOVERED HEAT - The temperature of the recovered heat energy dictates what it can be used for. The waste heat from a condensing turbine is nearly worthless, since it is at a temperature of 100 to 120 F. However, the

exhaust gases of a gas turbine are typically at 800 to 1000 F and can be used to generate low pressure steam or fire an absorption chiller system. Consequently, it is not just the Btu's of waste heat available, but their temperature that dictates their usefulness.

6) OPERATION AND MAINTENANCE - The operation of a multimillion dollar gas turbine requires considerably more technical know-how than that provided by ordinary maintenance mechanics. If proper maintenance procedures are not routinely implemented, the performance and life of the system can be significantly impaired. Any such system should probably be expected to require its own special operator or crew.

One cannot look at the cogeneration equipment alone and determine its projected effectiveness. The load (building) will play an important part in terms of what it requires of the system. Consequently, there are several criteria which should be analyzed in the building as well for cogeneration suitability.

1) SIZEABLE, STABLE LOADS - As mentioned above, rejecting waste heat to a cooling tower or selling electricity to a utility are to be avoided in an ideal system. A practical design will probably implement both of these to some extent, but hopefully they will be minimized by not having the loads fluctuate widely.

2) HIGH ELECTRIC RATES, MODERATE GAS RATES - While high electric rates are undesirable, facilities which have them are the prime candidates for cogeneration. Equally high gas prices diminish the savings of a cogeneration unit; so a large electricity/gas price differential is required for a reasonable payback. Some utilities in Texas still charge their customers below 4 cents per kWh, making any sort of cogeneration uncompetitive unless gas can be obtained at bargain prices.

3) INTEGRATION INTO EXISTING ENERGY SYSTEMS - Since this study mostly examines retrofit options, cost effectiveness will be enhanced if some of the existing equipment can be utilized. Agencies with their own chiller systems can normally interface directly with a cogeneration system, whether electric driven or absorption. Boilers may have to be modified, but often can be used as well. Usage, rather than replacement, of existing equipment will greatly improve paybacks if the equipment efficiency is comparable to current products.

Small Scale Cogeneration

For this study, small scale cogeneration will be defined as any system with an electrical output below 1000 kW. This size represents approximately the bottom end at which gas turbine engines can be economically competitive. Therefore, small scale cogeneration will encompass only diesel engines as the prime mover. Fuel cells would also fit into this category, but their technology has not reached widespread commercialization and will not be considered.

The market for which small scale cogeneration can be most advantageous is the single commercial building which has steady electrical and thermal loads nearly 24 hours a day. Most hospitals fit this category, while most office buildings do not. Hospitals use large amounts of low temperature heat for hot water, for low pressure steam and for space conditioning 24 hours a day. In addition, their electricity demand is almost constant since kitchens, laundries, and diagnostic equipment are used daily. On the other hand, office buildings are typically occupied only 9 to 10 hours a day, and often not at all on the weekends. Their usage may not exceed 50 hours a week, or 30% occupancy. As a result, the payback period for an office building cogeneration system can be expected to be nearly double that of a hospital. The office building will have large amounts of thermal heat unused and a lot of excess electricity sold at or below the cost to generate it. Cogeneration for office buildings could be practical only when it represents a fairly small percentage of the building's peak loads.

The difficulty with small scale cogeneration in the past has been the cost to design the small unit. Design and field fabrication time made the cost per kW excessive. Because of the tremendous health care market potential, a number of companies are entering the market with package cogeneration systems which are basically turnkey operations requiring very little on-site construction. These systems remove the engineering work from the small agency, and require the agency to deal with only one vendor, rather than the dozens which would be used for a custom designed unit. The cost per kW for these units typically run in the $1200 and higher range. While larger systems may cost less per kW, the overall costs of operating personnel and maintenance favor the package systems. These systems commonly offer many of the same features found on the larger, field-erected systems.

The small scale package cogeneration systems are perfect matches for many of the state's hospitals which are separated from any other agency or campus. A unit could be placed in a back parking lot right next to the building with no significant visual or noise problems. In addition, it would serve as a backup electrical source in case of a major power outage. There are possibly other agencies which have suitable applications for these units, such as some of the state's boys schools where a significant amount of floor space is classified as residential, being conditioned 24 hours a day.

Large Scale Cogeneration

Flexibility, operating efficiency, and cost per kW generally improve with the size of the unit. Therefore, it would pay in most cases to have a single large unit rather than multiple small package units. The size of the facility being served obviously dictates the maximum size of the cogeneration unit. There are a number of state universities which have fairly compact campuses, and are served by central chiller plants, which provide a good opportunity for cogeneration. The classroom buildings provide the lighting and space conditioning load by day while dormitories provide the hot water and space conditioning load at night. Some of the larger hospital facilities would fit into this category; however, many of them already are involved with some form of cogeneration operation.

Both diesel and gas turbines are commonly used in the 1000 kW and larger systems. Diesel engines have higher electric conversion efficiencies but lower temperature thermal energy than gas turbines. Gas turbines would be the system to choose if the thermal heat can best be utilized in the form of low temperature steam or possibly absorption cooling. The first cost of these systems can easily be below $1000 per kW, depending on size and the form of heat recovery which is used. Because of their greater complexity, specially trained mechanics would be required to operate or repair such systems.

Cogeneration Economics

As with any type of investment, an appropriate return on capital is to be expected when investing in cogeneration equipment. Simple payback is most easily calculated and is often used although it is usually recognized that the breakeven point will differ from the simple payback number. The lack of assumptions about future fuel prices, inflation rates, interest rates and the like make such an analysis convenient to get quick comparisons of various investment options. Simple payback is found by dividing the capital cost by the first year savings. In the case of cogeneration, the savings are represented by displaced utility costs plus any sales of electricity or thermal energy, less the cost of operation.

The scope of this study is not to provide detailed engineering analyses of all the prospective cogeneration sites at the state agencies, but rather to indicate those sites which should investigate that option. The easiest method to use for such an analysis is a simple go/no go type of test. In this approach you simplify the problem by reducing the number of variables to the primary ones, you use fairly optimistic assumptions, and then if a facility does not indicate cost effectiveness, it is immediately eliminated from further consideration. Those facilities which pass the evaluation could then be given a more rigorous examination relying on more operating data.

To simplify the payback considerations, one must first look at the simplest definition of payback:

$$\text{PAYBACK} = \frac{\text{COST OF COGENERATION EQUIPMENT}}{\text{ELEC. SAVINGS + THERMAL SAVINGS - FUEL COSTS}}$$

For the very optimum operating conditions, no electricity is sold nor is any useful thermal energy wasted (100% utilization). The electricity savings are calculated based on the average rate for purchased power. For simplicity, demand charges will be rolled into the energy charge (per kWh) since the agency data did not list demand and energy charges. Thermal energy savings are found by determining how much primary energy is displaced by the recovered waste heat. This figure is calculated by taking the recoverable waste heat and dividing by the efficiency of the current heating equipment. In terms of an hourly gas flow rate in MCF, Q:

$$\text{COST} = (\$/\text{kW}) \times \text{kW} = (\$/\text{kW}) \times n_e \times Q \times (1{,}000{,}000/3{,}413)$$

Based on OH operating hours per year,

$$\text{ELEC. SAVINGS} = n_e \times Q \times \text{OH} \times (1{,}000{,}000/3{,}413) \times (\$/\text{kWh})$$

$$\text{THERMAL SAVINGS} = (n_o - n_e) \times Q \times \text{OH} \times (\$/\text{MCF})/n_b$$

$$\text{FUEL COSTS} = Q \times \text{OH} \times (\$/\text{MCF})$$

where n_e is the electrical conversion efficiency

n_o is the overall conversion efficiency (elec.+thermal)

n_b is the efficiency of the existing heating equipment

(\$/kWh) is the combined energy and demand charge

(\$/MCF) is the cost per thousand cubic feet of gas

PAYBACK is the payback period in years

When these expressions are put into the simple payback equation, one gets:

$$\text{PAYBACK} = \frac{\$/\text{kW}}{\text{OH}\left[\frac{\$}{\text{kWh}} + \left[\frac{n_o - n_e - n_b}{293\, n_b\, n_e}\right]\frac{\$}{\text{MCF}}\right]}$$

To reduce the number of variables involved, let it be assumed that:

$n_o = 0.75$

$n_b = 0.70$

OH = 8000 hours per year

With these assumptions, one can solve for the required electricity cost needed to make the system pay off in a specified amount of time.

$$\text{¢/kWh} = \frac{\$/\text{kW}}{80(\text{PAYBACK})} + \frac{n_e - 0.05}{2.05\, n_e}\left[\frac{\$}{\text{MCF}}\right]$$

Obviously the first term on the right is the contribution of the first cost while the second term accounts for operating costs. This relationship is most conveniently represented in graphical form with two independent parameters. The equation is fairly insensitive to electrical efficiency, so there are three independent variables of significance. To illustrate the relationships, Figure 2 shows cents/kWh versus $/kW and $/MCF for a fixed 4 year payback. Figure 3 shows cents/kWh versus payback and $/MCF for $1000/kW capital cost. For both figures, if the intersection of gas versus electric costs intersects below the appropriate line for capital cost or payback, then the system will not be cost effective. Points above the appropriate line show areas of good cost effectiveness. Again, it should be pointed out that this analysis is simply for the purpose of quickly eliminating about half the agencies from consideration for cogeneration equipment based on optimistic analyses.

Table 17 summarizes the results of applying this very simple analysis to the various state agencies when $1000/kW is used as the capital cost figure. It may be appropriate to summarize the assumptions which went into the generation of Table 17. These assumptions are:

1) All electricity which is produced is consumed on site. None is sold to the local utility. Electric costs have been based on a cents/kWh basis, averaging demand charges in with the energy charges.

2) All available thermal energy is assumed to be utilized. None is considered

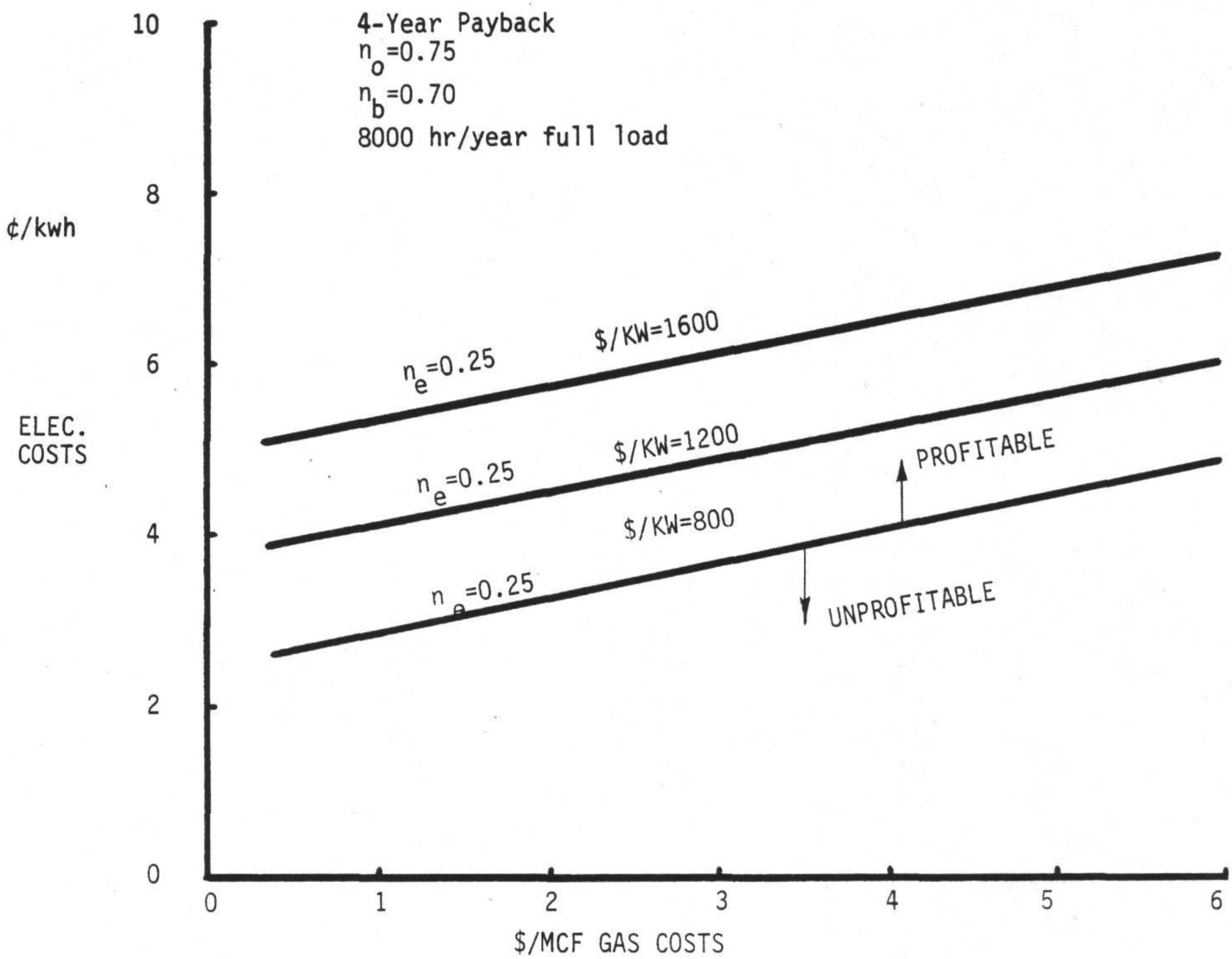

Figure 2 Electrical Prices Needed for Cost-Effective Cogeneration

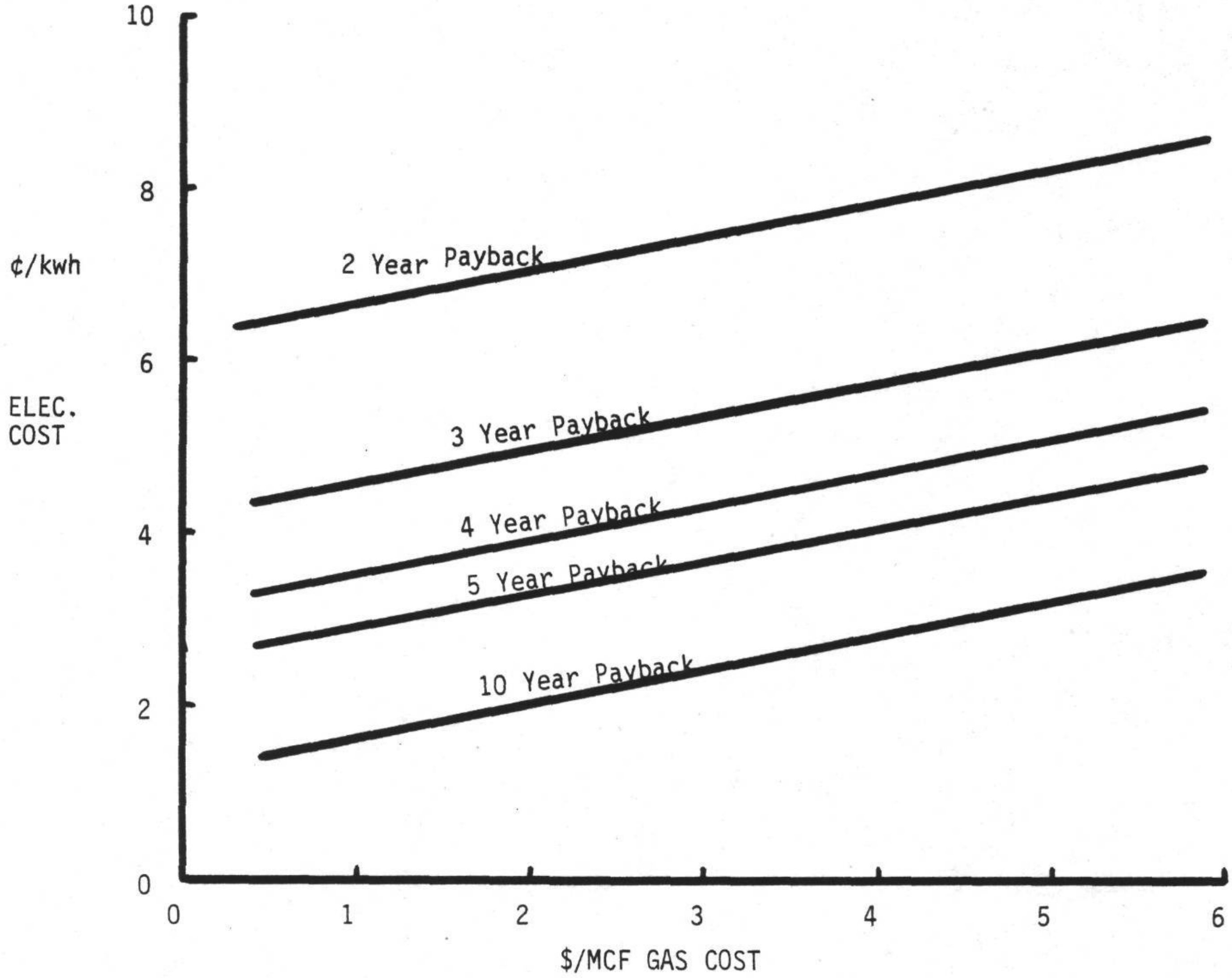

Figure 3 Simple Payback as a Function of Fuel Costs for Cogeneration

to be dumped to cooling towers if it could be used for some other purpose.
3) Electric conversion efficiency is 25%, overall energy recovery is 75%, and the efficiency of existing heat generating equipment is 70%.
4) Cogeneration equipment cost is $1000/kW. This does not include costs of chiller equipment or boilers used in conjunction with the system, nor does it include the distribution system which would normally be an external cost anyway.

When the agency data are analyzed for average fuel costs, the two graphs illustrate those which should consider investigating cogeneration and those which should not. From the data, it generally indicates that agencies in the Houston, Corpus Christi, and Austin areas already have electric rates suitable for cogeneration. Agencies in the eastern portion of the state (in the Gulf States Utilities service area) are currently borderline cases. However, GSU will be losing a very favorable long term gas contract on January 1, 1985 resulting in a steep rate increase. The agencies in the Dallas area have reasonably favorable electric rates, making cogeneration somewhat marginal in that area.

The payback figures in Table 17 should not be taken as absolute, but rather a means of comparing the potentials of all the agencies very quickly. Based on the assumed $1000/kW first cost, the cutoff point for consideration should probably be those agencies which have a 3 year or less payback time. There are 19 such agencies listed. The lowest payback is 2.4 years for UTEP, but most are in the 2.8 to 3.0 range. While these numbers may be considered borderline for some private investors, it should be kept in mind that the price of gas is expected to be fairly stable over the next 5 to 10 years while the price of electricity in Texas is expected to rise dramatically due to expiration of long term gas contracts and bringing expensive lignite and nuclear plants on line in the next year. Also, these numbers are already out of date, being 1983 averages. Consequently, if 1985 costs could be accurately forecast, these payback figures would possibly be no more than half of the listed values. Private investors are well aware of these situations, which explains the number of third party cogeneration companies in existence.

There are several agencies which should be discussed with regard to their cogeneration potential. UTEP and Pan American have very short payback periods, yet the listed figures may be misleading since both purchase their thermal energy. Consequently, their first costs would be larger than other agencies where an existing physical plant could be interfaced with the cogeneration

Table 17 Average 1983 Gas and Electricity Prices and Cogeneration Payback Period for State Agencies

STATE AGENCY OR INSTITUTION	GAS COMPANY OR UTILITY	1983 AVG. GAS PRICE ($/MCF)	1983 AVG ELEC. PRICE (CT/KWH)	COGEN PAYBACK PERIOD (YRS)
UNIVERSITY				
Angelo State University	LONE STAR GAS CO.	5.23	5.9	3.2
Corpus Christi State Univ.	CITY OF CORPUS CHRISTI	5.75	6.3	3.1
Lamar University	ENTEX, INC.	5.02	3.7	7.0
Midwestern State Univ.	LONE STAR GAS CO.	5.02	5.0	4.2
North Texas State University	LONE STAR GAS CO.	5.37	6.0	3.2
Pan American University	RIO GRANDE VALLEY GAS CO.	5.27	6.6	2.7
Prairie View A&M University	CITY OF HEMPSTEAD(?)	4.26	4.9	3.9
Sam Houston State University	ENTEX, INC.	5.57	4.4	5.6
Stephen F. Austin State Univ.	ENTEX, INC.	5.39	4.2	5.9
Sul Ross State University	SOUTHWEST TX MUN. GAS	2.94	5.4	3.0
Tarleton State University	LONE STAR GAS CO.	4.33	5.2	3.5
Texas A&I University	ENTEX, INC.	5.29	6.3	2.9
Texas A&M Univ. (Galveston)	SOUTHERN UNION	5.83	6.0	3.4
Texas Southern Univ.	ENTEX, INC.	4.18	5.8	3.0
Texas Tech Univ.	ENERGAS COMPANY	3.78	5.9	2.8
Texas Woman's Univ.(Dallas)	LONE STAR GAS CO.	4.76	4.6	4.5
Texas Woman's Univ.(Denton)	LONE STAR GAS CO.	4.22	6.0	2.9
U.T. Arlington	LONE STAR GAS CO.	4.16	4.3	4.6
U.T. Dallas	LONE STAR GAS CO.	5.15	4.7	4.7
U.T. El Paso	SOUTHERN UNION COMPANY	4.23	6.8	2.4
U.T. Inst. of Texas Culture	SOUTHERN UNION COMPANY	5.65	5.8	3.5
U.T. San Antonio	SAN ANTONIO PUB. SER.	5.08	5.2	3.9
U.T. Tyler	ENTEX, INC.	5.79	4.7	5.2
U.T. of the Permian Basin	ENERGAS COMPANY	3.80	5.8	2.9
Univ. of Houston(Clearlake)	ENTEX, INC.	5.60	6.0	3.3
Univ. of Houston(Downtown)	ENTEX, INC.	5.56	6.0	3.2
Univ. of Houston, Univ. Park	ENTEX, INC.	5.61	5.7	3.6
West Texas State Univ.	ENERGAS CO.	4.08	5.4	3.3
HEALTH CENTERS				
Texas Tech Univ. Health Sci.	ENERGAS COMPANY	3.81	5.6	3.0
U.T. Cancer Center	ENTEX, INC.	5.62	5.8	3.4
U.T. Health Center at Tyler	ENTEX, INC.	3.90	4.2	4.6
U.T. Health Science, Houston	ENTEX, INC.	6.15	5.8	3.7
U.T. Health Science, S.A.	SAN ANTONIO PUB. SER.	3.69	5.1	3.4
U.T. Heath Science, Dallas	LONE STAR GAS CO.	4.87	4.4	4.9
U.T. Med. Branch Galveston	SOUTHERN UNION COMPANY	6.17	5.8	3.7
DEPARTMENT OF CORRECTIONS				
Retrieve Unit	ENTEX, INC.	4.81	6.2	2.9
Coffield, Beto Units	LONE STAR GAS CO.	5.22	6.0	3.2
Clemens Unit	ENTEX, INC.	4.82	6.1	3.0
Darrington Unit	ENTEX, INC.	4.80	5.8	3.2
Eastham Unit	ENTEX, INC.	5.65	5.4	4.0
Ellis Unit	ENTEX, INC.	5.65	5.3	4.0
Ferguson Unit	ENTEX, INC.	5.65	5.4	3.9

Table 17 (cont.)

Mt. View, Hilltop, Gatesville	LONE STAR GAS CO.	5.99	6.0	3.4
Goree	ENTEX, INC.	5.69	5.2	4.2
Huntsville	ENTEX, INC.	5.69	5.2	4.1
Jester, Central Units	ENTEX, INC.	4.66	5.5	3.4
Pack I Unit	TEXAS SOUTHEASTERN, INC.	4.27	5.7	3.1
Pack II Unit	TEXAS SOUTHEASTERN, INC.	4.26	5.5	3.3
Ramsey Unit	ENTEX, INC.	4.65	6.0	3.0
Wynne, Windham, Diagnostic	ENTEX, INC.	5.72	5.4	3.9
DEPARTMENT OF HEALTH	SOUTHERN UNION COMPANY	5.00	6.5	2.8
South Texas Hosp.	RIO GRANDE VALLEY GAS CO.	5.32	6.4	2.9
San Antonio St. Chest Hosp.	SAN ANTONIO PUB. SER.	4.70	6.0	3.0
DEPT. OF MEN. HEALTH & MEN. RET				
Austin State Hosp.	SOUTHERN UNION COMPANY	5.30	6.2	3.0
Rusk St. Hosp.	ENTEX, INC.	5.65	4.7	5.0
San Antonio St. Hosp.	SAN ANTONIO PUB. SER.	4.69	5.4	3.5
Terrell St. Hosp.	LONE STAR GAS CO.	4.36	4.5	4.4
Wichita Falls St. Hosp.	LONE STAR GAS CO.	4.34	4.9	3.9
Abilene St. Sch.	LONE STAR GAS CO.	4.47	5.5	3.4
Austin St. Sch.	SOUTHERN UNION COMPANY	5.46	6.5	2.8
Denton St. Sch.	LONE STAR GAS CO.	5.41	6.1	3.2
Mexia St. Sch.	LONE STAR GAS CO.	5.39	5.3	4.0
Richmond St. Sch.	ENTEX, INC.	4.82	5.8	3.2
Travis St. Sch.	LONE STAR GAS CO.	5.26	6.4	2.9

system. If one assumed $300 per ton additional cost for a chiller plant, the payback would be over 3 years for both of these agencies. A prime candidate for cogeneration is Texas Tech University. Tech has a large physical plant in place (although technically not owned by the University) which could easily tie in with a cogeneration system. In addition, a large scale system could be installed due to the large stable load, decreasing the first cost to probably somewhere in the $700-800/kW range, making the payback even more attractive than that shown. Two of the prison units have a 3 year payback, but probably are not good candidates for cogeneration because of their unsteady load. Much of their electrical demand is associated with their industrial usage, which is closely tied to the regular work day of the inmates, normally 8 to 5 shifts. In addition, inmate labor would be used to operate the system if it were installed. The complexity of any system would have to be kept to a minimum because of the lack of skilled operators. The expected poor maintenance record of such a system would largely negate any energy savings it might produce.

There are two special cases which should be mentioned. UT-Austin and the capitol complex (Purchasing and General Services) are two extremely large users. The capitol complex pays high electric rates. A facility which could serve both agencies could take advantage of economies of scale as well as diversified loads. The close proximity of the two would be a very distinct advantage. However, to avoid an expensive wheeling charge to the city of Austin for transferring the generated electricity from one agency to the other, a separate connection would have to be made, increasing the first cost. If the two agencies could work out some of the logistics, primarily rates and supply schedules, the added cost of a fairly short electrical connection could easily be absorbed into the overall cost. A thermal energy connection may be more costly due to excavation of city streets, so one agency (probably UT) should use all the thermal energy on site. A similar arrangement exists between Sam Houston State University and the TDC Huntsville Unit. However, there is an open space between the two which would be amenable to laying power or steam lines. The facility could be run by Sam Houston State, selling the power and thermal to the TDC. It should be noted that the paybacks of either of these two agencies do not fall in the below 3 year criterion suggested above. Here is a case where 1985 prices will probably completely change the economics of the situation since both of these agencies are serviced by Gulf States Utilities. While these agencies do not fall in the suggested range for further consideration, their combination should be given special attention based on larger than normal future rate increases.

There are three hospitals with paybacks below three years: South Texas Hospital, San Antonio Chest Hospital, and Austin State Hospital. Hospitals in general provide excellent opportunities for cogeneration, so these particular ones become the first choices for applying cogeneration in the health care sector. The two state schools with acceptable paybacks would have to be looked at in more detail to see if their loads would be acceptable for cogeneration to be profitable.

Cogeneration Financing Options

All of the various types of cogeneration systems are extremely expensive propositions. For instance, a quite small 400 kW package system that would be suitable for a small hospital would cost in the vicinity of half a million dollars. A 4 MW unit would cost about 4 million dollars. While these figures may seem acceptable compared to the state's 250 million dollar annual utility bill, one must realize that there are probably a couple of dozen locations which are prime candidates for cogeneration. Such a request for state funds would not have a high probability of winning approval of the state legislature. There are other options which may be even more favorable for the state. This discussion lists the major avenues which the state could pursue in promoting cogeneration at a number of its major agencies.

1) STATE FUNDING - This method would call for appropriations from state funds to construct cogeneration equipment on a one time basis. The total cost for the best 10 projects would probably cost in excess of 40 million dollars. The average payback would probably be about 2.5 to 3 years, yielding the state an annual utility savings of about 12 to 15 million dollars. The probability of success in passing such a bill is unknown; however, if it failed on the first try, that would mean an additional 2 to 3 years before anything is done. Other options look more attractive for cogeneration at the state agencies.

2) STATE BONDS - The state of Texas could issue bonds to cover the cost of construction of these facilities. The good credit rating of the state would insure a reasonably good interest rate. However, with the cost of money at about 12% now, the payback of the systems would be longer, since over 5 million dollars a year goes just for interest. However, the state could still realize a net savings of 7 to 10 million dollars with no up front money from the

legislature.

3) *THIRD PARTY FINANCING* - This arrangement calls for an outside firm to construct a cogeneration facility on the agency's site and to sell the produced energy to the agency at a price below the current utility prices. Third party arrangements are particularly attractive to investment groups because of the favored tax status and the fairly quick payback which they receive. Including tax credits, they typically stand to gain about a 20% return on investment. There is no up front cost to the state, but the savings will not be as large as if they did it themselves. A number of arrangements could be worked out with the firm, from them selling the energy directly, to them leasing the plant to the agency for a fixed fee with the agency and its personnel controlling the operation. While this is a fairly recent development in cogeneration, there are literally dozens of companies who are in this sort of business. Table 18 has a list of some projects currently under study in the Houston area by one such firm.

SUMMARY

There are a number of opportunities for significant energy savings for state agencies by implementing cogeneration methods. Sizeable reductions in the state's utility bill could be obtained, but at the expense of millions of dollars in capital equipment costs. Because of the lack of readily available funds for such construction, third party financing may be the quickest and most effective method to get these systems started up as soon as possible. This route would keep the state's budget in line and would essentially farm out all the detailed design work to specialty firms rather than to overworked engineers already on state staff. The state would not be liable for any loss due to poor design or changing economic conditions. The preferred method of implementing such a project would be for the state to request bids from such firms on an all or any combination arrangement. This procedure would probably reduce the bureaucratic red tape of having each individual agency make its own arrangement, at a poorer bargaining position.

Another advantage of using a centralized approach to cogeneration evaluation is that state level interagency arrangements could be made to benefit the state as a whole. For example, a single cogeneration system could be placed on Sam Houston State University property to serve both SHSU and the Department of

Table 18 Third Party Cogeneration Projects

DECKER ENERGY INTERNATIONAL, INC.

Projects Under Study In The Houston Area

INSTITUTION	SIZE (KW)	SAVINGS (1986 $/YR)	PAYBACK (YEARS)
Univ. of Houston	12,000	$4,200,000	1.9
Rice University	4,000	$1,600,000	2.5
Thermal Energy Co-Op.*	9,000	$3,610,000	2.1
Methodist Hospital	3,000	$1,240,000	2.2
N. W. Medical Center	700	$250,000	2.8
Mem. Hosp. of Galveston Cty.	470	$170,000	2.7
	29,270	$11,070,000	

* Thermal Energy Cooperative supplies heat, chilled water and water most of the Houston Medical Center.

Corrections Huntsville Unit. Similar arrangements could be made for UT-Austin and the capitol complex or Texas Woman's University and North Texas State University. However, each agency would be reluctant to propose such a system since it would involve another state agency's approval. A single supervisory group to oversee the awarding of contracts could evaluate such proposals in the best interests of the state and negotiate with both agencies to win final approval.

Because of the fairly long lead times involved with these processes, it is hoped that the state of Texas will act decisively to initiate some sort of cogeneration policy on a statewide basis. The potential is present for saving millions of dollars annually from the state's utility budget. With third party financing, there is essentially no cost or risk to the state, with much to be gained.

RECOMMENDATIONS

The following is a list of recommendations for further action regarding cogeneration at various state agencies.

1) Electricity costs are such that many of the state's largest agencies could significantly reduce their utility bill with cogeneration. Appropriate action at the state government level should be taken to proceed at once with plans to construct cogeneration facilities at selected sites.

2) A particular agency or group should be assigned the responsibility to see that cogeneration plans are brought to completion within the next two to three years.

3) Third party financing should be given prime consideration as the means to develop cogeneration to its fullest extent in as short a time as possible. This method of financing costs the taxpayers of Texas nothing, provides federal tax incentives for Texas businesses, insures proper engineering design of cogeneration plants by experts in the field, places no financial risk whatsoever on the state of Texas, may enable cogeneration facilities to be operational as soon as 1985, and could easily save the state over $20 million per year in fuel costs.

4) The agency or group mentioned above should secure third party financing on an "all or any combination" arrangement. This method would provide for competitive bidding, yet not exclude some of the smaller firms which may perform quite well on a smaller scale. This bidding should take place as soon as the candidate agencies have been given a detailed look at their potential for

cogeneration.

5) Based on a simple economic assessment of cogeneration potential, the following agencies represent first (but not exclusive) choices for investigation of cogeneration:

Texas Tech University
University of Texas at El Paso
Pan American University
Austin State Hospital
San Antonio State Chest Hospital
South Texas Hospital

There are several other special cases where two agencies are in close enough proximity to one another that a cogeneration facility could be shared. These agencies are:

Texas Woman's University/North Texas State University
U.T. Austin/Capitol Complex (UT already cogenerates)
Sam Houston State University/TDC Huntsville Unit

CHAPTER 5

ENERGY RECOVERY FROM BURNING OF MUNICIPAL SOLID WASTE

Introduction

Energy recovery from the incineration of solid waste is a viable energy alternative. On the average, each pound of refuse contains about 4500 Btu. This is roughly one-half to two-thirds the energy content of lignite and approximately one-third that of a high-grade coal. Despite its low heating value, each pound of refuse, when burned in an energy recovery unit, will produce from 2.2 to 2.7 pounds of steam. The refuse should be regarded as a resource rather than burying it in a landfill.

The most widely used method of deriving energy from refuse is incineration. The technology which is the most advanced is mass burning using waterwalled incinerators. These plants are complex and require expensive pollution control equipment, but they are the most efficient. The waterwalled incinerators burn the refuse on a moving grate using excess combustion air. The walls of the furnace are literally watertubes, and heat is transferred to the water walls both by convection and gaseous radiation. Additional heat is transferred from the hot gases in the traditional convective boiler tubes. Most of the U.S. waterwalled incinerators have a capacity in excess of 350 tons/day [13].

Incineration of refuse using smaller, modular units is more likely for most applications in the state. The modular units are typically waste heat recovery boilers, and are somewhat less efficient in their conversion efficiency. They will generally produce from 2.2 to 2.4 pounds of steam for each pound of refuse incinerated. The modular units have great flexibility. They can be purchased in many sizes, and several could be used together to obtain the desired daily tonnage.

Refuse-to-Energy Systems at TDC

Of the many state agencies, the Texas Department of Corrections (TDC) is the only one known to burn refuse for energy recovery. Five modular incinerators with energy recovery either are in operation or have been purchased for the TDC. The following table summarizes the TDC operations.

Table 19 Energy-from-Waste Systems at TDC

Gatesville

Model:	Consumat Model C-225/ML-350
Capacity:	850#/hr
Operation:	Intermittent (Manual feed and manual ash removal)
Current schedule:	8 hrs/day, Monday, Wednesday, & Friday
Product and use:	Steam is used for laundry and food services

BETO I

Model:	Consumat Model CS-1000
Capacity:	1650#/hr
Operation:	Designed for continuous operation-ramfeed and continuous ash removal system
Current schedule:	8 hrs/day, 5 days a week
Product and use:	steam is fed into steam lines which is used to drive a 300-ton absorption chiller

Ellis II

Model:	Conserthern HV-130, Manufactured by Industronics, Inc.
Capacity:	1800#/hr
Operation:	Designed for continuous use
Current schedule:	not operational-awaiting state permits
Product and use:	steam produced will drive a turbine-generator. 250kW of power will be used for sewer plant operation.

PACK I and RAMSEY III (2 units)

Model:	Conserthern HV-130, manufactured by Industronics, Inc.
Capacity:	1800#/hr
Operation:	Designed for continuous use
Current schedule:	Both PACK I and RAMSEY III units are scheduled for completion in early 1985.
Product and use:	the steam will be fed into the steam lines of the unit.

The Gatesville unit, as currently operated can process about 10 tons of refuse/wk. Since it is a manual operation, there is little potential for growth or increased usage.

The BETO I unit is located outside of Palestine, Tx. and serves BETO I, BETO II, and the COFFIELD units. Under a 5-day a-week schedule it could process approximately 30 tons of refuse per week. If operated on a 24-hr. schedule, 7 days a week, the unit could handle in excess of 100 tons of refuse per week. This is far more refuse than is generated by the prison units, and the prison incinerator could handle a portion of the refuse from the City of Palestine. This could be a small source of revenue for the prison system and a large piece of goodwill in that the prison would reduce the volume and weight of the refuse sent to a sanitary landfill. Increasing the operation to 24 hours a day, 7 days a week would, however, present operational problems for the prison officials. The current shift operation of 8 hours a day is in part determined by the one-shift operational schedule for inmates.

The ELLIS II unit, when operational, will serve eight units in and around Huntsville. These units are: FERGUSON, EASTHAM, ELLIS I, II, WYNNE, DIAGNOSTIC, HUNTSVILLE, and GOREE. A total of 15,000 inmates usually reside in those units. Their waste plus that of the employees and the industrial wastes generated could amount to over 20 tons/day. In order for the ELLIS II waste heat recovery incinerator to handle all of the trash from these eight units, it would have to operate on a 24 hour a day basis. Expected energy recovery would be approximately 2400 Btu's of steam/pound of refuse. Since the ELLIS II energy recovery unit will produce 250 kW, the resulting savings from a 24-hour operation will be 76,440 dollars per year.[+] In addition to the dollar savings, the refuse volume to be landfilled will be reduced by approximately 90%, thus extending the life of landfill. If the unit operates only 8 hours/day, then the equivalent dollar savings will be cut 2/3.

The most cost effective use of the steam produced by waste heat boilers will be in the PACK I and RAMSEY III units. The steam produced will be used directly as process steam. Each pound of refuse will produce about 2.4 pounds of steam. The PACK I energy recovery unit will serve only about 3000 inmates plus the employees, and its operation will be severely limited. It will probably operate only 1 shift a day, processing less than 4 tons/day. The city of Navasota could provide additional refuse, but the usefulness of this unit is questionable. Processing 4 tons/day, the unit's annual savings would be

[+]Assumes 250 kw production for 6132 hours per year at $0.05/kwh.

$25,000.*

The RAMSEY III energy recovery unit could service RAMSEY I, II and III, plus the DARRINGTON unit. The expected refuse is approximately eight tons/day, which will require slightly more than a normal one-shift operation. On this basis the unit could generate the equivalent of $50,000/year in avoided costs of producing steam from natural gas. No large cities are located close enough to this unit which is in Brazoria County SW of Alvin, to enable it to contract for outside refuse.

The usefulness of energy-recovery from refuse units in the TDC is questionable from an economic viewpoint. Experience with large mass-burning units in the U.S. has indicated that they are technically difficult to operate, and they must operate as much as possible, i.e., 24 hours a day, 365 days a year if they are to be economic. [13] Although the prison work force is cheap, they are virtually unskilled and are not dedicated or motivated to energy recovery from refuse operations. Present TDC policy prevents anything more than a one-shift operation. Although there are more reasons than economic ones to incinerate refuse and recover the energy, i.e., extend the life of sanitary landfills, deposit in the landfill an inert residue or ash as opposed to raw or unprocessed refuse, and to destroy difficult to handle waste items such as unusable rubber tires, there is little to be gained from the present TDC operation of energy-from-refuse systems. The amount of energy saved from these operations is small compared to the potential in other areas.

State Agency Refuse-to-Energy Systems

There are other possibilities where energy-from refuse-systems could be installed and be economic. At the same time a contribution could be made to the surrounding cities where landfills are being operated. For many cities, solid waste disposal is becoming a major problem. Urban sprawl has forced the closing of close-in landfills, and distant landfills make disposal of refuse more expensive. In some areas there are no suitable sanitary landfills. For any energy-recovery system to be successful there have to be four main ingredients: an adequate supply of refuse; a good technical system; good management/labor force; and a market for the product, whether it be steam, chilled water, or electricity. Few of the agencies/ institutions, by themselves, will qualify on all four items. Although virtually all of them would have a market for the produced steam, few would have an adequate supply of refuse or the technical

*Assumes equivalent price of steam displaced is $5/1000#.

capability to operate an energy-from-waste system.

By combining agencies/institutions with municipalities, some combinations could result in viable systems. Such interactions between different governmental entities are not without precedent in the solid waste industry. The most successful example is the Hampton, VA, refuse-to-energy plant. Hampton is an example of city-federal cooperation. The plant was designed by engineers from NASA/Langley, is operated by the City of Hampton, and the facility burns refuse collected from Hampton, NASA/Langley, a nearby VA hospital, and Langley Air Force Base. The steam produced is sold to NASA/Langley. This relationship has worked very well. [13]

A second example is in Portsmouth, VA. The incinerator plant, run by the federal government, burns refuse from the City of Portsmouth. [13]

There are several locations which look like good candidates for refuse-to-energy systems. Such would involve a cooperative effort between one or more state agencies and one or more municipalities. Three specific sites will be discussed.

City of Galveston/University of Texas Medical Center-Lone Star Energy Company

The city of Galveston is located on Galveston Island, and there are no suitable landfills on the island. The refuse is trucked 20 miles to the mainland for disposal. A study conducted for the City of Galveston by RAS Associates in 1980 discussed the refuse disposal alternatives for the city. Because of the long trucking distances, refuse disposal costs are high. There is also a ready market for the steam produced. Lone Star Energy Company (which sells steam to the UT Medical Center) would be the primary customer. There would also be the possibility that the steam could be sold directly to the UT Medical Center when the contract with Lone Star Energy expires.

The facility could be operated by the state, burn the City's refuse, and provide steam to the UT Medical Center. Alternatively, the facility could be run by the city or by a third party, could burn the refuse form the City and the UT Medical Center, and could then sell the steam to Lone Star Energy or to the Medical Center.

The size of the system needed would be approximately 200 tons/day, which places it in the range of a small waterwalled facility the size of the Hampton, VA, plant. Several modular units would also be possible. The following table shows some of the expected economics and energy match with the UT Medical

Center.

Table 20 Refuse-to-energy system at Galveston

Capital Cost, 200 ton/day plant (1984$)		- 10 Million
Expected Annual O&M Costs	- $5000/avg. daily throughput	- $750,000
Steam produced, based on 75% availability and 60% conversion efficiency		- 300×10^6 lb/year
Expected Revenues	- tipping fees @ $15/ton	- $1.1 Million
	- sale of steam @ $4.50/1000#	- $1.35 Million
Total steam needs at UT Medical Center (FY '83)		- 300×10^6 lb/year

On an annualized basis, the steam produced from the refuse-to-energy plant looks like a perfect match for the UT Medical Center. On a monthly basis the match is not that good because of the variation in steam demands. Some months require more steam than would be produced by the refuse-fired plant, and some months require less. Overall, however, the Medical Center would be a good customer for the refuse-fired steam plant.

Bryan/College Station/Texas A&M University

The combined population of the area exceeds 100,000 people. Including refuse from Texas A&M there will be approximately 150 tons of refuse generated per day. This amount of refuse places it in the size of both large modular and small mass burning, waterwalled incineration units. The location of the unit could be in several places which would be beneficial to all parties. Texas A&M needs steam and chilled water for its expanding West Campus, and the central power station cannot handle the extra loads. A refuse-fired incinerator on the West Campus would be a much shorter haul for both Bryan and College Station garbage trucks, and both cities would pay a tipping fee to A&M for disposal of their refuse. A&M would be able to use the energy for steam production. A second possibility for location at Texas A&M would be in their new industrial park. One of the most attractive offers which can be made to any industry is the promise of cheap energy. With tipping fees from the refuse of Bryan and College Station, plus reduced disposal fees for A&M, a refuse-fired steam plant could offer steam at a price cheaper than the companies could generate it themselves. A third location for the plant would be the Bryan industrial park, but this location would probably have to be a municipality-owned or a third party financed plant.

Denton/North Texas State University/TWU

Although smaller in population than the Bryan/College Station area, the same potential exists. The combined refuse would be around 100 tons/day. Either NTSU or TWU would have a 24-hour market for most of the steam produced. A modular incinerator with a waste-heat boiler would probably be preferable to a waterwalled incinerator unit in Denton.

Summary

Refuse-to-energy systems are a viable alternate energy source. Energy from refuse can be economic in those instances where there is adequate refuse and a need for the end product-usually steam. The refuse-to-energy systems are capital intensive, and they also require skilled workers to maintain them. There are some identifiable candidates for refuse-to-energy systems which warrant additional studies; however, the payback period for a plant is very long. There are reasons other than economic, of course, for installing energy recovery systems, but if the state of Texas is interested in implementing energy conservation programs, there are many opportunities which can result in shorter paybacks. A moderate-sized cogeneration system, for instance, could be installed for the same price as a refuse-to-energy system, and the payback period would be much faster. About the same technical skills would be required, but the reliability and availability of the cogeneration plant would be higher. The refuse-to-energy systems should be considered as a long-term conservation opportunity rather than a short-term, fast payback venture.

Recommendations

There are no specific, near term recommendations for refuse-to-energy systems at the state agencies. The technology exists for these energy-recovery systems, and if a particular state agency felt they had a need for such a system, then the feasibility should be considered. The proposed purchase of any additional energy-recovery units by the TDC should be carefully examined in the future.

Chapter 6

FORMATION OF POWER AGENCIES AND GEOGRAPHIC LOAD MANAGEMENT

These two topics were reviewed to see if there would be instances where they would be applicable to state agencies. The original concept was to see if several agencies would be able to combine as a single entity and bargain with the utilities for a better rate structure. The logic behind such a move would be that combined agencies might be able to smooth out some of the electrical demand rates and be considered as a unit rather than as two or more separate agencies. Also, a larger entity might be able to negotiate a more favorable utility rate than several smaller agencies. Although there would be problems getting inter-agency cooperation, and there would not be an energy reduction, as such, there could have been a reduction in energy costs. Examples could include the Sam Houston State University and the TDC Huntsville unit, the several different state institutions in the Medical Complex in Houston, the state institutions in Galveston, or TWU and North Texas State in Denton.

From a legal view point, a political entity, called a power agency, which would have the ability to negotiate rates, sell bonds, etc., cannot be formed by state agencies. The legislation which authorized the formation of a joint powers agency is Chap. 10, Title 28, of the Revised Civil Statutes of Texas, 1925, as amended. Section 2, title 32, article 1435a, requires the participating agencies to be "engaged in the generation, transmission, or distribution of electric energy for sale to the public." None of the state agencies are currently involved in the sale of electrical energy; hence the formation of power agencies is not an option.

Geographic load management, particularly for Sam Houston State University and the Huntsville prison unit is briefly discussed in the "Cogeneration Opportunities" chapter of this report. Since the legislation is not in place which would allow agencies to "pool" their energy demands and allow them to negotiate with utilities for more favorable rates, it is unlikely that voluntary inter-agency cooperation could accomplish much in cost reductions. There are some interesting observations which can be made when one compares electrical rates even for institutions within the same agency. Consider the electrical rates for the UH system for FY '83 shown in Table 17. The rates range from a low of 5.66 /kwh at the main campus to a high of 6.04 /kwh at UH-downtown. All campuses are served by HL&P. If the rates for the UH system were determined by system demand instead of the consumption at each campus, then the rates might even be lower than the 5.66 /kwh paid by the main campus. It is difficult sometimes to get institutions within the same system together, and inter-agency cooperation will even be more difficult.

Energy conservation and sound energy management practices within the agencies appear to offer more favorable long-term energy and cost reductions.

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APPENDIX A

CLIMATIC ANALYSIS OF AGENCY ENERGY CONSUMPTION DATA

THE EFFECT OF LOCAL WEATHER PATTERNS ON EUI

It is no secret that the local weather conditions play a significant role in determining how much energy is consumed in order to properly heat and air condition a building. Numerous computer studies and field tests have verified that buildings in the south generally use less energy for space conditioning than the same building located in the northern part of the country. Because of the large size of Texas, both in the north-south and east-west directions, weather variations may be expected to cause significant differences in energy consumption.

The simplest method to account for weather variation is to simply look at the heating and cooling degree days as tabulated by the National Oceanic and Atmospheric Administration. These values are tabulated on a monthly basis along with average values over many years. Degree days account for only temperature-related weather conditions, and so could not be expected to give significant results for special constructions (passive solar designs) which make special use of solar radiation. However, the buildings which comprise most of the agencies in Texas are not so designed, making the degree day method at least a good approximation on an annual basis.

There are three areas which could be evaluated using degree day data. They are:

1) Normalization of monthly energy use data to that for an average weather month. Ideally such an approach would make the energy use curves from different years collapse to a single curve by eliminating the weather variability.

2) Normalization of annual energy use data to that for an average weather year. This method would allow for a proper comparison of energy usage trends from one year to the next. Weather patterns can easily cause monthly usage to vary by 10% or more. Such differences may be experienced during years of extremely hot or cold weather.

3) Normalization of annual energy use data to that for an average weather year at some specific location in Texas. A simple comparison of energy utilization indexes (EUI) for all agencies is somewhat misleading because of their different climates. It is to be expected that the agencies in the northern part of the state would need to use more energy than those in the south. Consequently, a true comparison of EUI's cannot be made until the agencies are evaluated under essentially the same weather conditions. This

comparison can be approximated using the degree day approach.

1) MONTHLY NORMALIZATION

Inspection of the monthly energy usage at the state agencies reveals how the consumption jumps rather erratically from month to month and from year to year. If these differences in energy use were due to weather differences, then the curves could be smoothed out by using average monthly degree day conditions.

The method which was used to normalize the energy use data is shown graphically in Figure A-1. The energy use of a building can be broken down into weather related (such as heating or cooling) and non-weather related (such as lighting) categories. If one were to examine the electrical energy use of an agency that heated with gas and cooled with electric drive air conditioning, the electricity usage would peak in summer and the gas usage would peak in winter. The electricity used in winter largely constitutes the base load, or non-air conditioning related uses, which exist year round. The gas used in summer represents the base load for gas. The area under the curve between the valley and the peak then represents the energy used to heat or cool and is influenced by the severity of the weather conditions. The base load is fixed and invariant with weather. The weather related energy usage can be normalized by simply multiplying the area under the peak curve by the ratio of average degree days to actual degree days, and adding it to the base load. This process can be applied to both monthly and annual data.

$$\text{Corrected energy use} = \text{Area under peak curve} \times \frac{DD_{ave}}{DD_{actual}} + \text{base area}$$

Figure A-2 shows the results of applying this procedure on a monthly basis to the electrical energy use data for FY'81 and FY'82 for San Antonio State Chest Hospital. It can be seen that normalizing tends to distort the energy use figures, particularly during mild weather. During months when the degree days were near normal there were very little differences. This method is particularly sensitive to mild weather months when the degree days are small. During those months, a very small difference in total degree days can produce a large percentage difference, blowing the apparent weather related effects out of proportion. It is precisely that effect which caused the December and February figures to be so out of line with the rest of the numbers.

The general conclusion from this simple exercise is that on a monthly basis, this degree day procedure is probably not precise enough to generalize

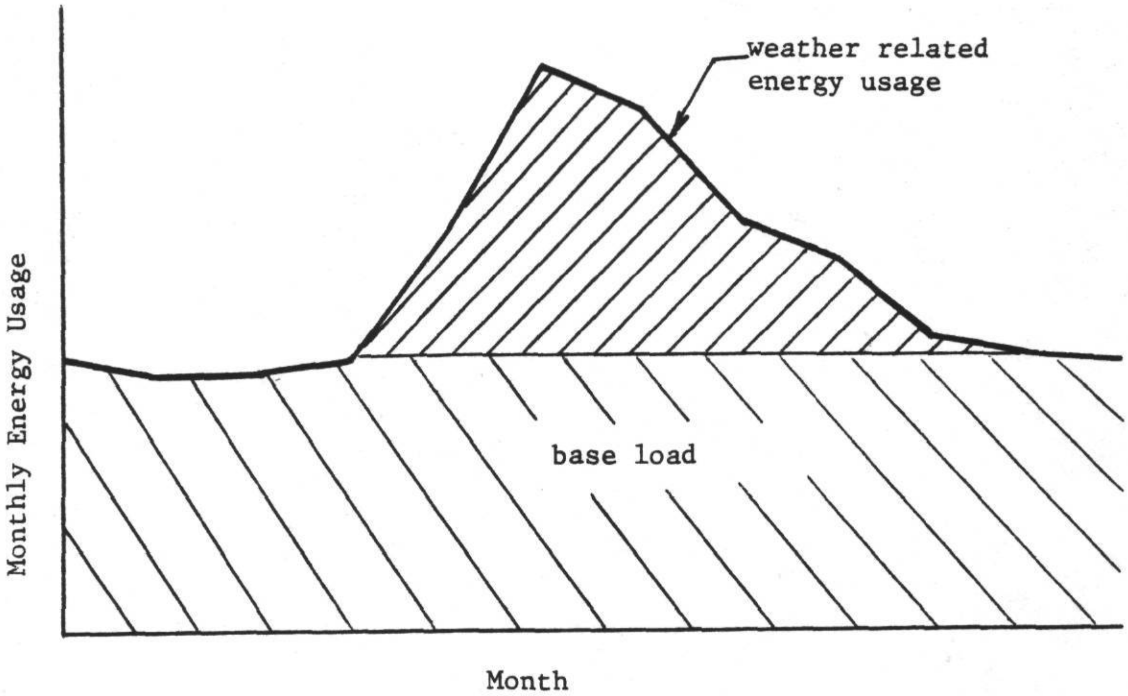


Figure A-1 Breakdown of Agency Energy Usage into Weather Related and Base Load Energy Usage.

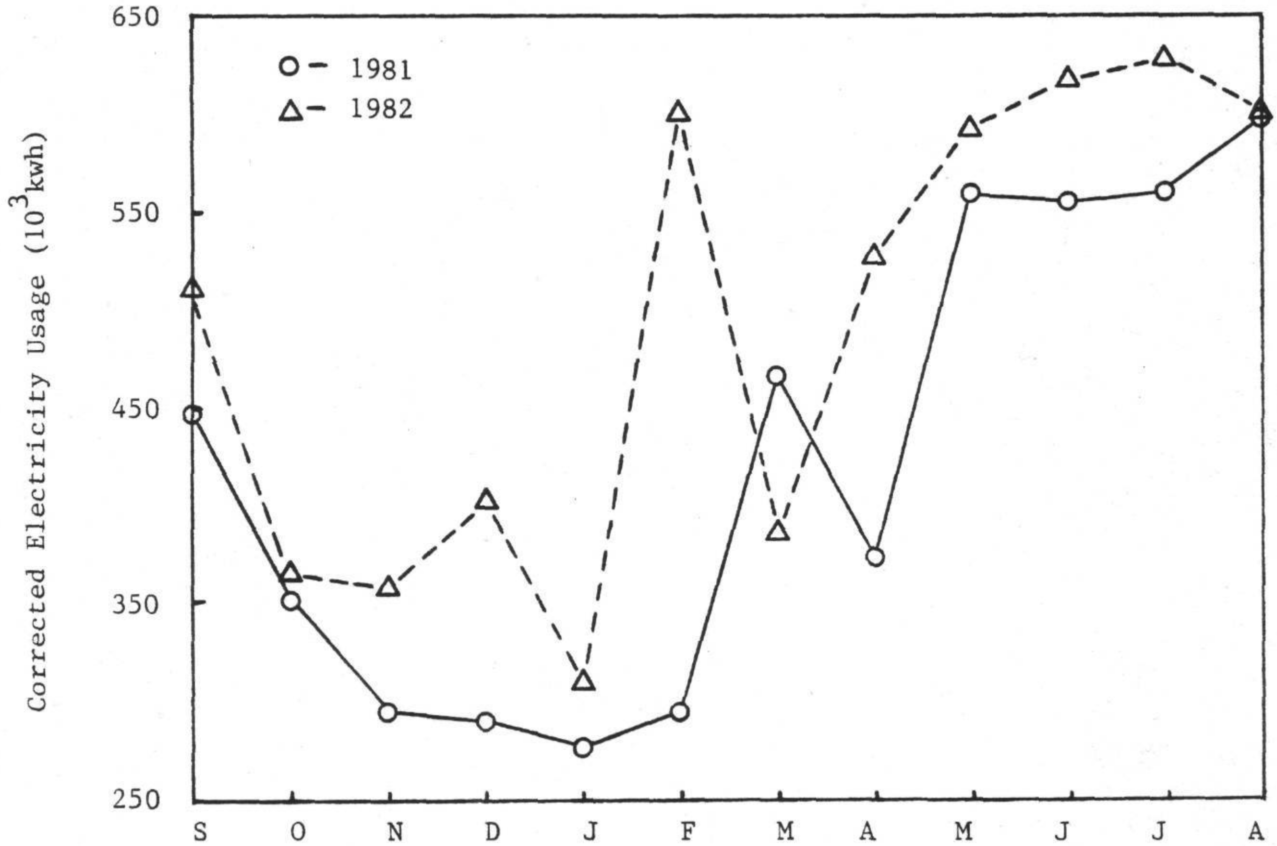


Figure A-2 Corrected Monthly Electricity Consumption for San Antonio State Chest Hospital for 1981 and 1982.

the consumption curves from one year to the next. No effort was made to normalize the monthly figures for all the state agencies.

2) ANNUAL NORMALIZATION

The comparisons of EUI's for the various state agencies shows some to be increasing at an alarming rate, as much as 10% per year. However, some of this increase could conceivably be attributed to differences in weather patterns. A comparison of weather data for the major cities in Texas reveals that FY 1981, 1982, and 1983 were near normal with respect to temperatures throughout Texas. However, to quantify the differences, Southern University was selected for comparison of 1981 to 1982 using normalized annual consumption figures. The same normalization process as described earlier was used. Table A-1 shows the results when the electricity and gas consumption data are both normalized and then converted to a resultant EUI. Both figures changed only slightly, with the difference from one year to the next almost unchanged. Therefore, one would have to conclude that the 10% difference in EUI from 1981 to 1982 was associated with factors other than weather.

Because of the very minor effect which weather would have had for the '81-'83 time period, no significant differences can be expected for any of the state agencies. If future years produce unseasonable conditions, such an analysis may be necessary to factor out the weather variable in order to see just how well the agencies are progressing.

3) ANNUAL NORMALIZATION TO AUSTIN WEATHER DATA

In order to compare the state agencies' energy usage equally, they should all be converted to equivalent weather conditions. This process involves a similar procedure as implemented above, but the average degree day data for one specific location is used for normalization purposes. Austin was chosen since it is most nearly in the center of the state, and since a large cluster of agencies are located there.

Two agencies were selected for this comparison. They were North Texas State University and Austin State Hospital. These agencies have the uniform

Table A-1 Corrected Energy Use for Southern University for FY '81, '82.

	1981			1982		
	Gas (MCF)	Electricity (10^3 kwh)	EUI ($Btu/yr/ft^2$)	Gas (MCF)	Electricity (10^3 kwh)	EUI ($Btu/yr/ft^2$)
Actual	92,179	30,822	223,869	111,501	31,944	250,000
Corrected	93,216	30,043	222,743	114,193	30,801	249,000
% difference	1.1%	-2.5%	-0.5%	2.4%	-3.6%	-0.4%

peaks and valleys which can best be used in the degree day analysis. These two agencies were "moved" about the state using degree day data to see how their energy usage would be influenced by different weather conditions. Using two representative agencies was preferred over normalizing all the different agencies since only the weather is changed. The process of comparing different agencies automatically introduces other factors into the analysis. Using a single university and hospital to typify a large part of the agencies to be considered reduces the number of variables which may cloud the issue.

Table A-2 shows the results of "moving" these two agencies to different places in the state. The differences between cities at the same north-south latitude can be seen to be quite small (Dallas, El Paso, Midland-Odessa). Very sizeable differences were seen between the extreme northern and southern parts of the state. With a location in Amarillo, the state hospital would use nearly 20% more energy than in Austin, but nearly 10% less when in Brownsville. The university would use nearly 35% more in Amarillo but 15% less in Brownsville. Thus, within the state of Texas, it should not be uncommon to see state agencies which may differ by 30% or more in their energy usage, even if they had nearly identical facilities. However, this analysis also puts an upper bound on how much of the differences between agencies can be attributed to weather, certainly not the factor of 3 or 4 which is seen in the tabulated agency EUI data.

Table A-2 Comparison of EUI for North Texas State University and Austin State Hospital Using Degree-Day Data from Various Texas Cities in FY'81

	NTSU		ASH	
Location	EUI ($Btu/yr/ft^2$)	% difference from Austin	EUI ($Btu/yr/ft^2$)	% difference from Austin
Austin	125,900	0	219,100	0
Dallas	139,300	10.6	231,700	5.8
Houston	120,100	-4.6	213,600	-2.5
Amarillo	168,700	34.0	259,000	18.2
Brownsville	107,300	-14.8	201,800	-7.9
El Paso	139,400	10.7	231,650	5.7
Midland-Odessa	139,500	10.8	231,700	5.8

APPENDIX B

ANNUAL AGENCY ENERGY DATA AND

AGENCY AREAS

MAJOR HEALTH CENTERS/HOSPITALS (PRODUCE THERMAL ENERGY)

AGENCY	YEAR	ELEC. (KWH)	NAT.GAS (MCF)	STEAM (MLBS)	CHLD.WTR. (TON HRS)	#2 OIL (GLNS)	BUTANE (GLNS)	AREA GROSS SQ.FT.
SAN ANTONIO STATE CHEST HOSPITAL	1981	5120000	60992	----	----	----	----	179194
	1982	5696000	66964	----	----	----	----	179194
	1983	5804800	69990	----	----	----	----	179194
WICHITA FALLS STATE HOSPITAL	1981	11047510	125612	----	----	490	----	597428
	1982	10855055	117956	----	----	9415	----	607132
	1983	10723292	114884	----	----	2910	----	607132
RUSK STATE HOSPITAL	1981	12714408	143858	----	----	----	----	725895
	1982	13269756	111025	----	----	----	----	725895
	1983	13136510	114313	----	----	----	----	725895
U T HEALTH CENTER AT TYLER	1981	10115000	64898	----	----	----	----	394000
	1982	11629000	65637	----	----	----	----	329000
	1983	10977000	59691	----	----	----	----	329000
TERRELL STATE HOSPITAL	1981	13651000	138775	----	----	----	----	769486
	1982	13325000	110993	----	----	----	----	769486
	1983	12799000	114423	----	----	----	----	769486
AUSTIN STATE HOSPITAL	1981	14118061	111187	----	----	----	----	743202
	1982	14115025	125363	----	----	----	----	743202
	1983	13511100	152834	----	----	----	----	
SOUTH TEXAS HOSPITAL	1981	3726000	16992	----	----	----	----	154380
	1982	4033800	14840	----	----	----	----	154380
	1983	4296700	13815	----	----	----	----	154380
SAN ANTONIO STATE HOSPITAL	1981	12050710	63818	----	----	----	----	621401
	1982	12529083	63418	----	----	----	----	621401
	1983	11866046	65272	----	----	----	----	621401

PURCHASE THERMAL ENERGY

AGENCY	YEAR	ELEC. (KWH)	NAT.GAS (MCF)	STEAM (MLBS)	CHLD.WTR. (TON HRS)	#2 OIL (GLNS)	BUTANE (GLNS)	AREA GROSS SQ.FT.
U T HEALTH SCIENCE CENTER AT HOUSTON	1981	43826464	5830	245703	27894788	----	----	1555678
	1982	45232922	3919	205123	30059153	----	----	1555678
	1983	45863324	3207	213248	29293095	----	----	1555678
TEXAS TECH HEALTH SCIENCES CENTER	1981	53412667	220174	263769	18779465	83934	----	811131
	1982	53909718	213828	240736	20691335	88863	----	811131
	1983	56613568	204665	264096	20760285	81328	----	811131

U T HEALTH SCIENCE CENTER AT DALLAS	1981	49434525	6972	205832	30812486	----	----	1902520
	1982	51045259	9200	186782	31540226	----	----	2040281
	1983	53509271	12164	196058	29600936	----	----	2040281
U T MEDICAL BR. GALVESTON	1981	69423349	28534	270337	47372241	----	----	2861260
	1982	73064250	29751	268408	49627018	----	----	3082994
	1983	80923673	24685	279458	52344769	----	----	3082994
U T SYSTEM CANCER CENTER	1981	86163802	217807	65167	17259050	----	----	2450124
	1982	86265205	193656	66363	18276750	----	----	2450124
	1983	85597460	177748	56008	17729290	----	----	2450124
U T HEALTH SCIENCE CENTER AT SAN ANTONIO	1981	34802414	3686	80004	14580038	----	----	1427718
	1982	36521390	5838	89536	14529914	----	----	1427718
	1983	38062091	7715	76327	12539884	----	----	1427718
UNIVERSITIES								
COGENERATING								
TEXAS A&M UNIVERSITY	1981	5753000	4517034	----	----	----	----	10855000
	1982	14717200	4387516	----	----	----	----	10855000
	1983	32870000	4048034	----	----	----	----	10855000
UNIVERSITY OF TEXAS AT AUSTIN	1981	23491892	4957765	----	----	24292	9693	12019982
	1982	26634415	5275819	----	----	69299	11173	12019982
	1983	28095701	5524454	----	----	2438	10018	12019982
PURCHASE THERMAL ENERGY								
U H UNIV. PARK (PHARMACY BLDG.)	1981	1290240	----	2290	----	----	----	49368
	1982	1390555	----	3342	----	----	----	49368
	1983	1400256	----	3225	----	----	----	49368
U T PERMIAN BASIN	1981	5832320	64148	23179	1578661	----	----	450842
	1982	6061539	67427	20439	1586922	----	----	450842
	1983	6344380	50997	18461	1418422	----	----	450842
TEXAS TECH UNIVERSITY	1981	53412667	220174	263769	18779465	----	----	6089689
	1982	53909718	213828	240736	20691335	----	----	6244246
	1983	56623568	204665	264096	20760285	----	----	6351535
U T SAN ANTONIO	1981	20526455	14238	43360	7693966	----	----	1056699
	1982	23300790	13546	59070	9415911	----	----	1150018
	1983	22480879	12445	60085	9190305	----	----	1151754

TWU HOUSTON CAMPUS								
	1981	3527048	0.4	101548	1714250	----	----	253170
	1982	3095472	1.8	155111	1893182	----	----	253170
	1983	3909984	2.6	241364	2789447	----	----	253170
PAN AMERICAN UNIVERSITY								
	1981	19922456	34684	----	5702293	----	----	942547
	1982	20382194	41919	----	6611914	----	----	953355
	1983	19895375	46736	----	6637711	----	----	953355
U T DALLAS								
	1981	20582088	7617	33811	5166801	26008	----	1040380
	1982	20757095	7834	33776	4814309	32869	----	1040380
	1983	20427447	7990	35518	4138309	13892	----	1040380
U T EL PASO								
	1981	30650553	30527	55830	8533914	----	----	2363098
	1982	31187071	25620	56782	9392959	----	----	2541351
	1983	33450273	31609	75307	9715690	----	----	2548299
U T TYLER								
	1981	7787069	15800	----	----	----	----	368439
	1982	7991612	48170	----	----	----	----	373229
	1983	8557389	18944	----	----	----	----	373229

PRODUCE THERMAL ENERGY

TEXAS A&M UNIVERSITY GALVESTON								
	1981	8244963	19486	----	----	----	----	147763
	1982	8486014	20455	----	----	----	----	147763
	1983	8585275	19759	----	----	----	----	147763
SOUTH WEST TEXAS STATE UNIVERSITY								
	1981	36399440	502779	----	----	----	----	2342653
	1982	40470266	579636	----	----	----	----	2481970
	1983	45451992	615046	----	----	----	----	2920754
LAMAR UNIVERSITY								
	1981	55490	116458	----	----	----	----	2058722
	1982	58431	128117	----	----	----	----	2121856
	1983	52534	144627	----	----	----	----	2262097
T W U DENTON CAMPUS								
	1981	21546368	410685	24000	----	----	----	1893586
	1982	23400060	397478	69281	----	----	----	1893586
	1983	20337208	387206	----	----	----	----	1893586
PRAIRIE VIEW A&M UNIVERSITY								
	1981	28498886	200380	----	----	----	----	1245807
	1982	30809908	175136	----	----	----	----	1245807
	1983	30773805	181791	----	----	----	----	1245807
U H - UNIVERSITY PARK								
	1981	126806184	722770	----	----	----	----	4916463
	1982	125890961	825826	----	----	----	----	4916463
	1983	133213922	968909	----	----	----	----	5048684

TEXAS SOUTHERN UNIVERSITY								
	1981	30821520	92179	----	----	----	----	896548
	1982	31943640	111501	----	----	----	----	895720
	1983	33340080	123867	----	----	----	----	895720
U T ARLINGTON								
	1981	58048565	325550	----	----	16490	----	2461715
	1982	62586638	387191	----	----	67178	----	2616719
	1983	64220385	348090	----	----	----	----	2686423
STEPHEN F.AUSTIN STATE UNIVERSITY								
	1981	60902425	204575	----	----	----	----	2400097
	1982	59613975	180547	----	----	----	----	2445592
	1983	59190978	197916	----	----	----	----	2616435
T W U DALLAS CAMPUS								
	1981	5597670	9997	----	----	----	----	199104
	1982	5525040	8344	----	----	----	----	199104
	1983	5710310	10358	----	----	----	----	199104
TARLETON STATE UNIVERSITY								
	1981	12432452	43625	----	----	----	----	810108
	1982	12289775	44206	----	----	----	----	852745
	1983	12132595	44941	----	----	----	----	897626
NORTH TEXAS STATE UNIVERSITY								
	1981	70374207	220835	----	----	----	----	3411594
	1982	64281378	219596	----	----	----	----	3411594
	1983	63901396	229856	----	----	----	----	3443403
MID WESTERN STATE UNIVERSITY								
	1981	13814026	57699	----	----	----	----	821719
	1982	12343807	50242	----	----	----	----	821719
	1983	12488908	54339	----	----	----	----	821719
WEST TEXAS STATE UNIVERSITY								
	1981	23941244	180073	----	----	----	----	2064008
	1982	24217983	177283	----	----	----	----	2064203
	1983	22949366	180294	----	----	----	----	2151267
SAM HOUSTON STATE UNIVERSITY								
	1981	48232199	87722	----	----	----	----	2209780
	1982	42832009	67772	----	----	----	----	2163474
	1983	39925077	65751	----	----	----	----	2057926
ANGELO STATE UNIVERSITY								
	1981	18434224	50917	----	----	----	----	1012244
	1982	17994337	49617	----	----	----	----	1012244
	1983	17489571	53866	----	----	----	----	1059420
CORPUS CHRISTI STATE UNIVERSITY								
	1981	13755340	4157	----	----	----	----	502225
	1982	14064340	3824	----	----	----	----	564543
	1983	14591145	4967	----	----	----	----	563945

U T INSTITUTE OF TEXAN CULTURES	1981	1877760	-----	3393	493714	----	----	165848
	1982	1905600	-----	5340	770979	----	----	165848
	1983	1900800	-----	3060	628077	----	----	165848
TEXAS A&I UNIVERSITY								
	1981	25236000	47168	----	----	----	----	1500000
	1982	26607600	38397	----	----	----	----	1500000
	1983	25838600	36245	----	----	----	----	1500000
U H - DOWNTOWN								
	1981	8674318	5325	----	----	----	----	483034
	1982	12006876	9922	----	----	----	----	533434
	1983	13107164	10686	----	----	----	----	560034
EAST TEXAS UNIV. TEXARKANA								
	1981	849800	458	----	----	----	----	51600
	1982	904200	833	----	----	----	----	51600
	1983	825720	502	----	----	----	----	51600
U H - VICTORIA								
	1981	652860	----	----	----	----	----	----
	1982	114593	147	----	----	----	----	----
	1983	831600	----	----	----	----	----	----
SUL ROSS STATE UNIVERSITY								
	1981	9855917	57699	----	----	----	----	380587
	1982	12343807	50241	----	----	----	----	380587
	1983	12488908	54339	----	----	----	----	380587
MAJOR STATE AGENCIES								
TDC COFFIELD AND BETO UNITS								
	1981	24360659	218353	----	----	----	----	880582
	1982	27576854	233156	----	----	----	----	1045124
	1983	25982013	305258	----	----	----	----	1488190
ABILENE STATE SCHOOL								
	1981	10850000	170961	----	----	----	----	627026
	1982	11194000	609728	----	----	----	----	606298
	1983	11323000	126884	----	----	----	----	606298
TDC DARRINGTON UNIT								
	1981	4600939	115093	----	----	----	----	396104
	1982	5055266	128435	----	----	----	----	410183
	1983	5924116	87217	----	----	----	----	512119
TDC GOREE UNIT								
	1981	3278452	37060	----	----	----	----	157369
	1982	3360216	41418	----	----	----	----	170737
	1983	3419816	48935	----	----	----	----	183877
TDC CLEMENS UNIT								
	1981	4079543	98932	----	----	----	----	377818
	1982	4466331	86032	----	----	----	----	444518
	1983	4302443	79926	----	----	----	----	444518

TDC EASTHAM UNIT								
	1981	5682708	157787	----	----	----	----	680882
	1982	6108610	159473	----	----	----	----	697382
	1983	6569525	162290	----	----	----	----	701532
STATE PURCHASING & GEN. SER. COMMISSION	1981	51584419	467837	----	----	----	----	3024432
	1982	57348781	356316	----	----	----	----	3090449
	1983	64249809	266976	----	----	----	----	3094353
TDC RAMSEY UNIT								
	1981	10746616	161632	----	----	----	----	770338
	1982	11433643	173458	----	----	----	----	795286
	1983	12471992	176528	----	----	----	----	937927
TDC WYNNE,DIAGNOSTIC&WINDHAM UNITS								
	1981	10761174	148882	----	----	----	----	738137
	1982	11326019	167957	----	----	----	----	822637
	1983	11260975	169547	----	----	----	----	822637
TDC RETRIEVE UNIT								
	1981	3398465	47825	----	----	----	----	242291
	1982	3617872	62010	----	----	----	----	242281
	1983	3524166	54807	----	----	----	----	249931
TDC HUNTSVILLE UNIT								
	1981	13304256	107785	----	----	----	----	635442
	1982	13577569	105412	----	----	----	----	635442
	1983	13795583	105237	----	----	----	----	635442
RICHMOND STATE SCHOOL								
	1981	11269368	64715	----	----	----	----	433183
	1982	11822287	59392	----	----	----	----	433183
	1983	11298832	59185	----	----	----	----	460980
TDC CENTRAL & JESTER UNITS								
	1981	8309169	160503	----	----	----	----	798768
	1982	9600229	188473	----	----	----	----	988010
	1983	12776820	262560	----	----	----	----	993010
TDC FERGUSON UNIT								
	1981	4802779	106376	----	----	----	----	531600
	1982	5425448	128515	----	----	----	----	545168
	1983	5440798	128379	----	----	----	----	545168
TEXAS DEPT. OF HEALTH								
	1981	11648400	29778	----	----	----	----	326300
	1982	10859600	30475	----	----	----	----	326300
	1983	10375200	28243	----	----	----	----	326300
TDC ELLIS UNIT								
	1981	8649025	132630	----	----	----	----	771034
	1982	8695372	149686	----	----	----	----	789876
	1983	9029757	151824	----	----	----	----	789876

T D M H M R	1981	195362821	1520953	----	----	490	6189	10415122
	1982	197596634	1443270	----	----	21035	5830	10567613
	1983	193901443	1441861	----	----	2910	6363	10706466
DENTON STATE SCHOOL	1981	10170843	59282	----	----	----	----	467248
	1982	8618343	63462	----	----	----	----	467248
	1983	6285706	58087	----	----	----	----	467248
TEXAS DEPT. HUMAN RESOURCES	1981	35314197	78819	----	----	----	----	1541239
	1982	33396534	64530	----	----	----	----	2066493
	1983	27438127	43706	----	----	----	----	2189507
AUSTIN STATE SCHOOL	1981	14118061	111187	----	----	----	----	576767
	1982	14115025	125363	----	----	----	----	576767
	1983	13511100	152834	----	----	----	----	576767
ADJUTANT GENERAL'S DEPT.	1981	3819900	20236	----	----	----	----	203761
	1982	4037467	21782	----	----	----	----	203761
	1983	4018240	22433	----	----	----	----	203761
MEXIA STATE SCHOOL	1981	10418776	67024	----	----	----	----	707229
	1982	10526648	57799	----	----	----	----	719116
	1983	10262742	64616	----	----	----	----	719116
TRAVIS STATE SCHOOL	1981	9004800	47441	----	----	----	----	512746
	1982	9031200	46152	----	----	----	----	512746
	1983	8589600	48318	----	----	----	----	512746
TDC MT.VIEW & GATESVILLE UNITS	1981	6056289	51485	----	----	----	----	521414
	1982	9518292	82298	----	----	----	----	835276
	1983	10823872	113360	----	----	----	----	850916
TEXAS DEPT. OF PUBLIC SAFETY	1981	20958391	46751	----	----	----	----	963836
	1982	19241864	45480	----	----	----	----	966180
	1983	17910894	32219	----	----	----	----	978932
STATE DEPT. OF HIGHWAYS & PUBLIC TRANSPORTATION	1981	45974239	273710	----	----	75144	----	3745251
	1982	48966676	273155	----	----	64084	----	3745251
	1983	50066605	310759	----	----	66733	----	3745251
TEXAS EMPLOYMENT COMMISSION	1981	28349968	32962	----	----	----	----	1323088
	1982	32441351	35110	----	----	----	----	1217606
	1983	32131952	36897	----	----	----	----	1231220

TEXAS PARKS & WILDLIFE DEPT.	1981	3332600	4544	----	----	----	----	168470
	1982	3523800	5162	----	----	----	----	168470
	1983	3293300	5085	----	----	----	----	168470
TEXAS DEPT. OF COMMUNITY AFFAIRS								
	1981	1470500	519	----	----	----	----	65738
	1982	1443000	619	----	----	----	----	55284
	1983	1111900	413	----	----	----	----	53628
TEXAS REHABILT. COMMISSION								
	1981	1549033	2292	----	----	----	----	117603
	1982	1448336	2124	----	----	----	----	107351
	1983	3342613	1626	----	----	----	----	214807
TDC PACK II UNIT								
	1983	3228091	42445	----	----	----	----	236567
TDC PACK I UNIT								
	1983	2414321	6368	----	----	----	----	139016

APPENDIX C

MONTHLY AGENCY ENERGY CONSUMPTION GRAPHS

Monthly Gas and Electricity Consumption

Monthly Gas and Electricity Consumption

Monthly Gas and Electricity Consumption

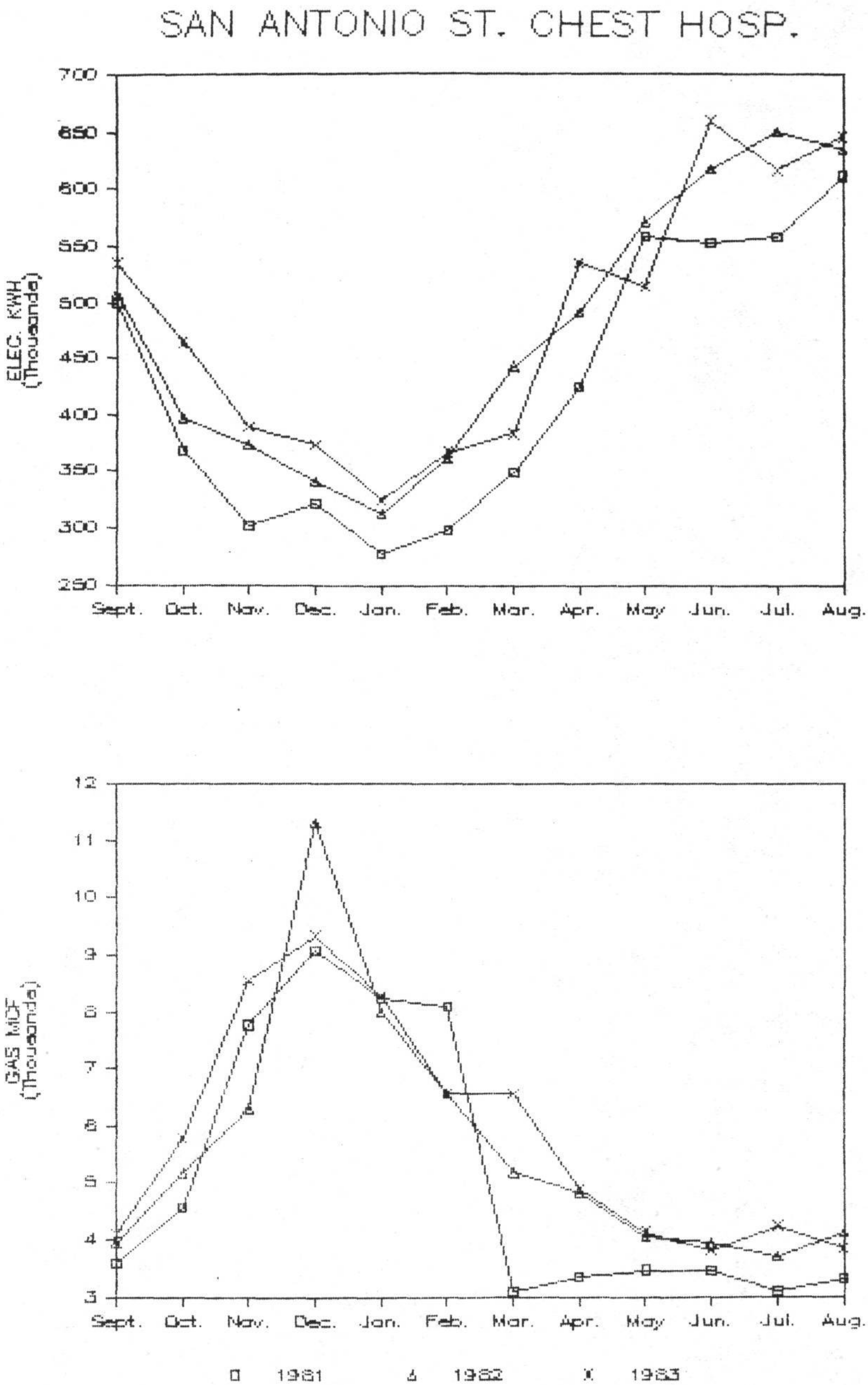

SAN ANTONIO ST. CHEST HOSP.
700
650
600
550
500
450
400
350
300
250
ELEC. KWH (Thousands)
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
12
11
10
9
8
7
6
5
4
3
GAS MCF (Thousands)
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
1981
1982
1983

Figure C-1

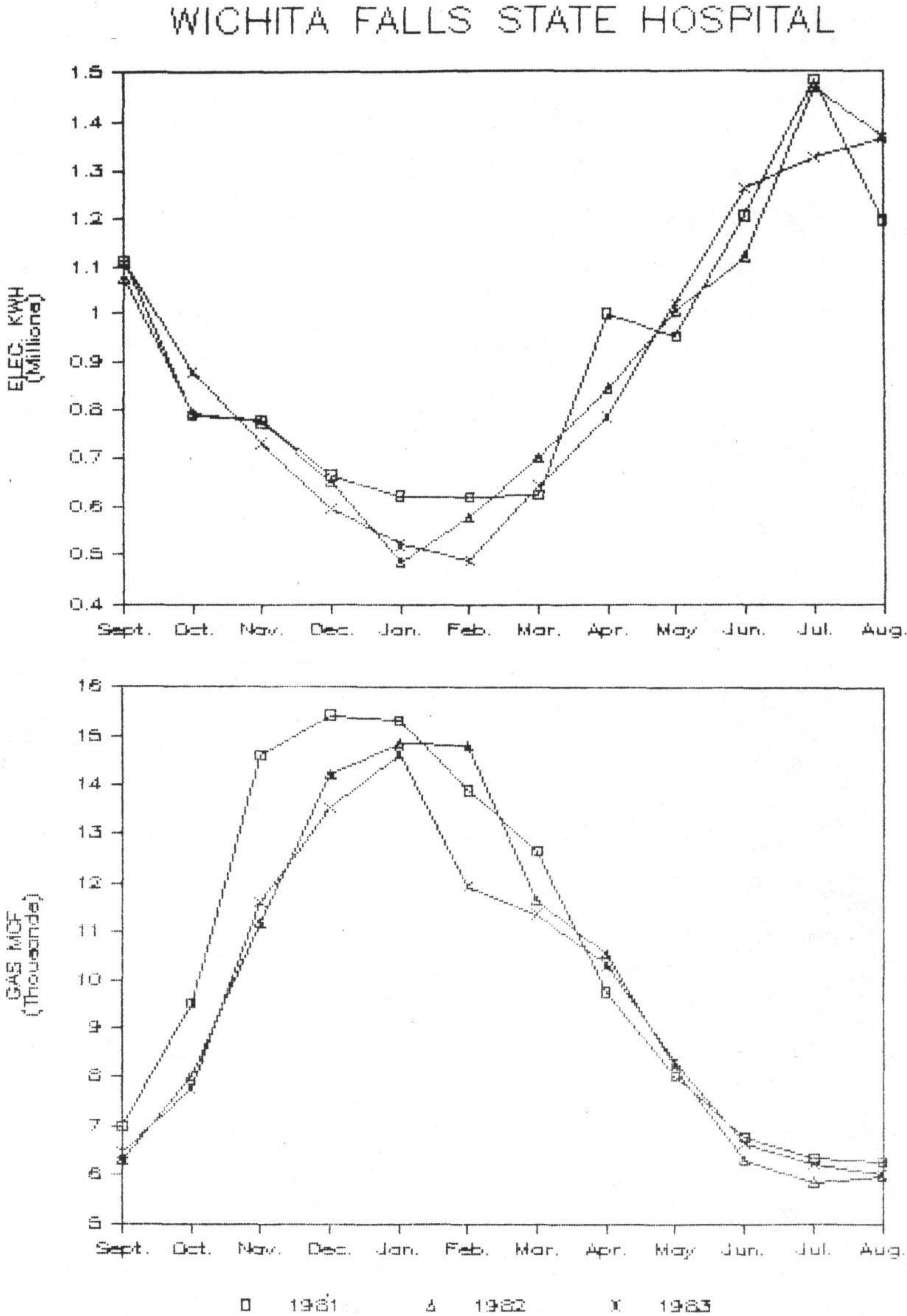

WICHITA FALLS STATE HOSPITAL
ELEC. KWH
(Millions)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF
(Thousands)
16
15
14
13
12
11
10
9
8
7
6
5
1981
1982
1983

Figure C-2

RUSK STATE HOSPITAL

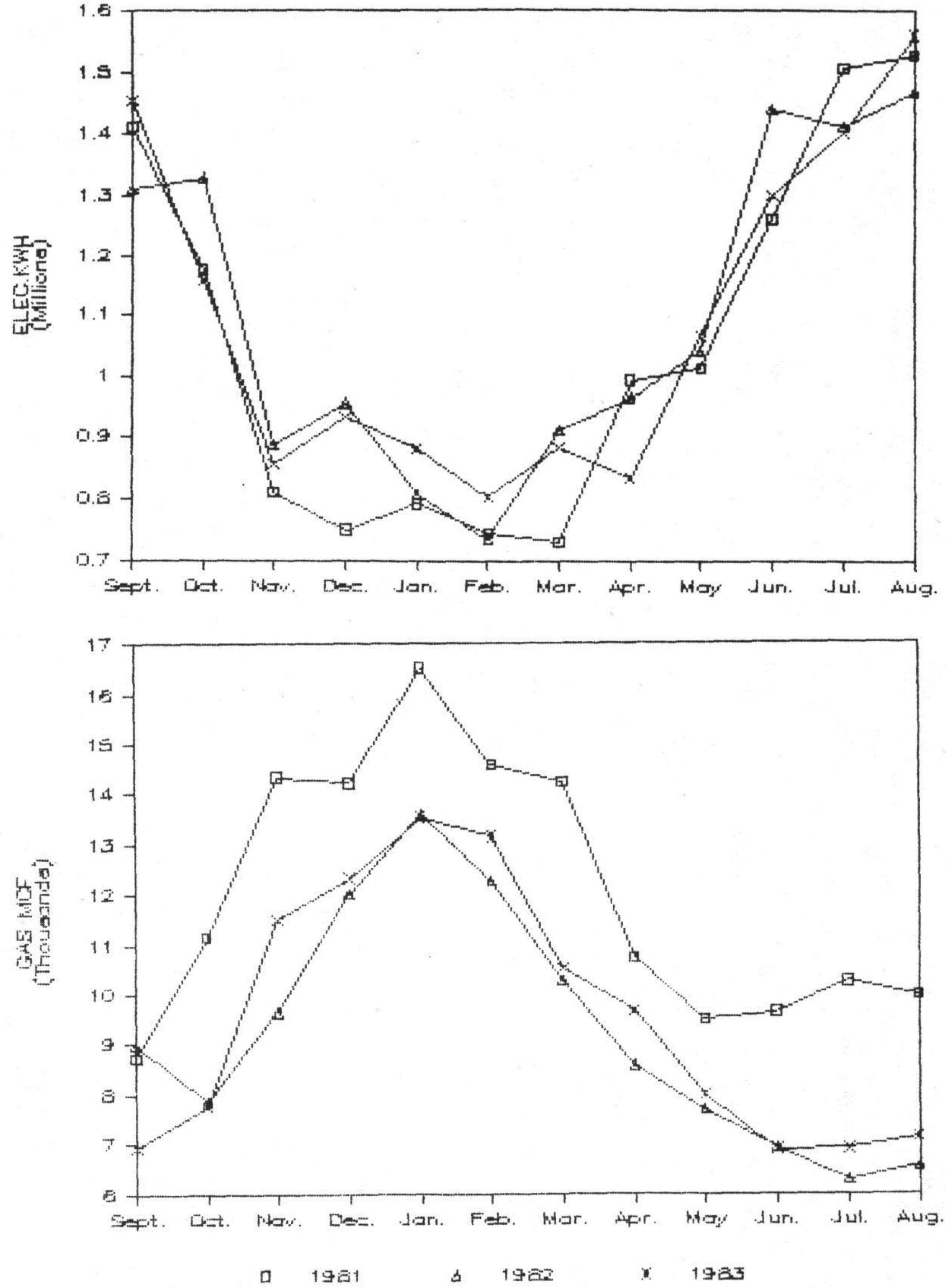
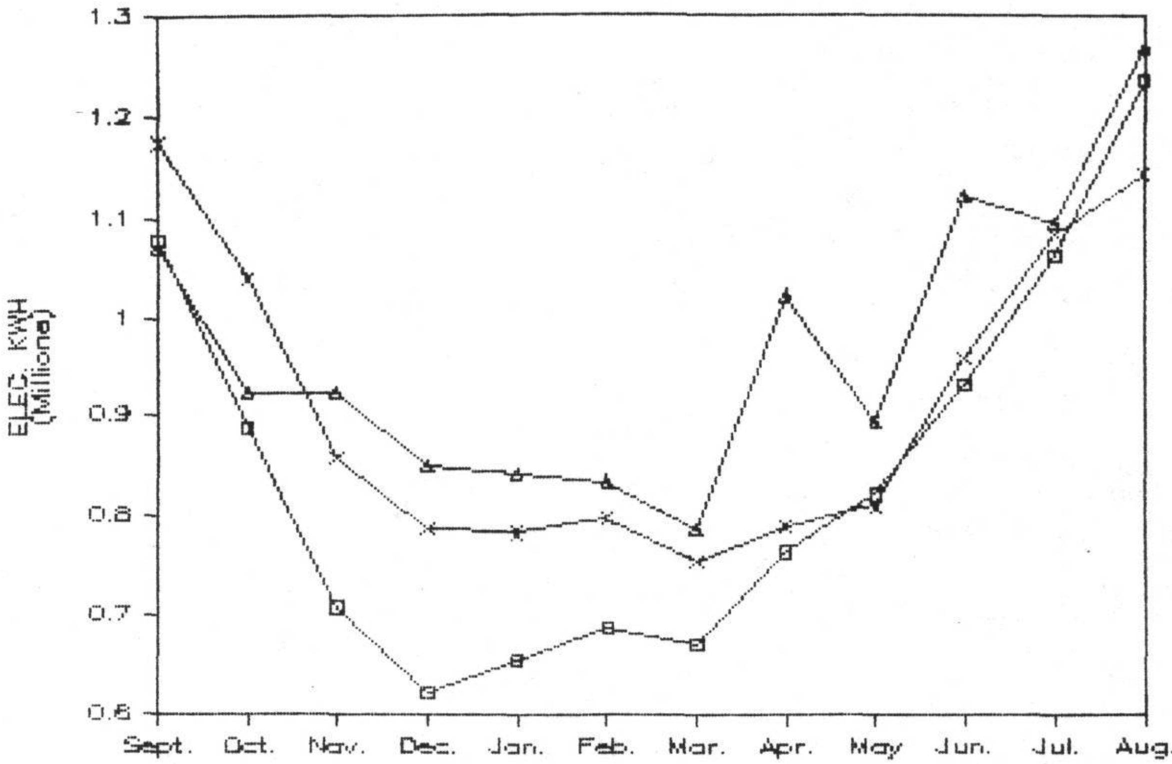


Figure C-3

U T HEALTH CENTER AT TYLER



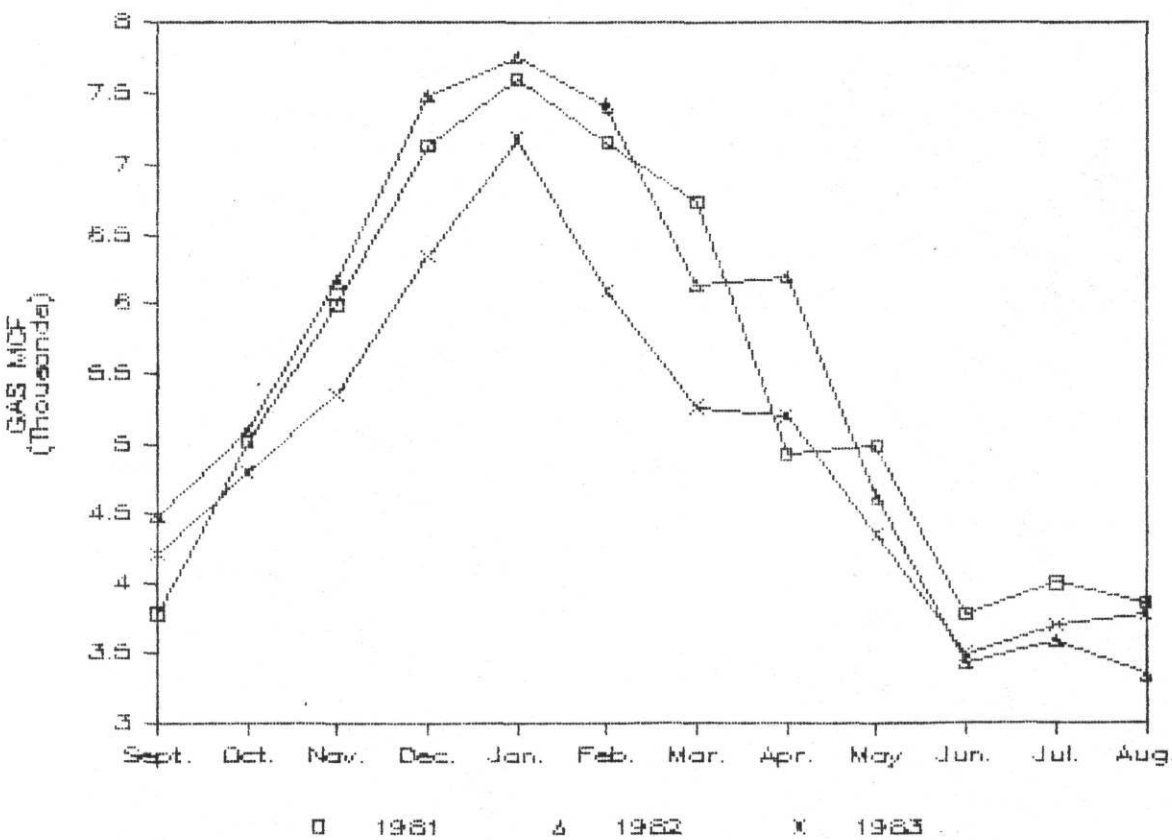


Figure C-4

TERRELL STATE HOSPITAL

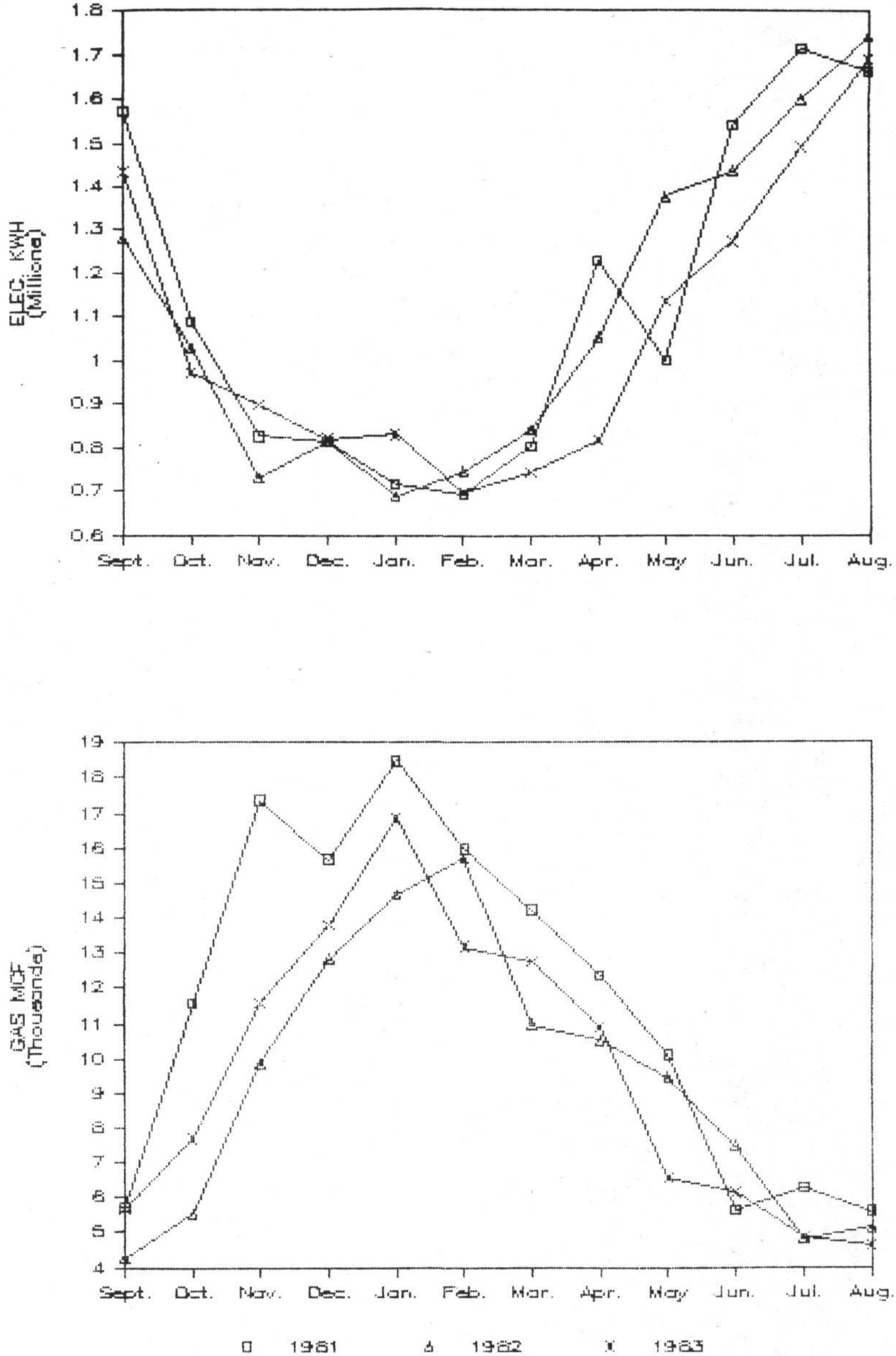
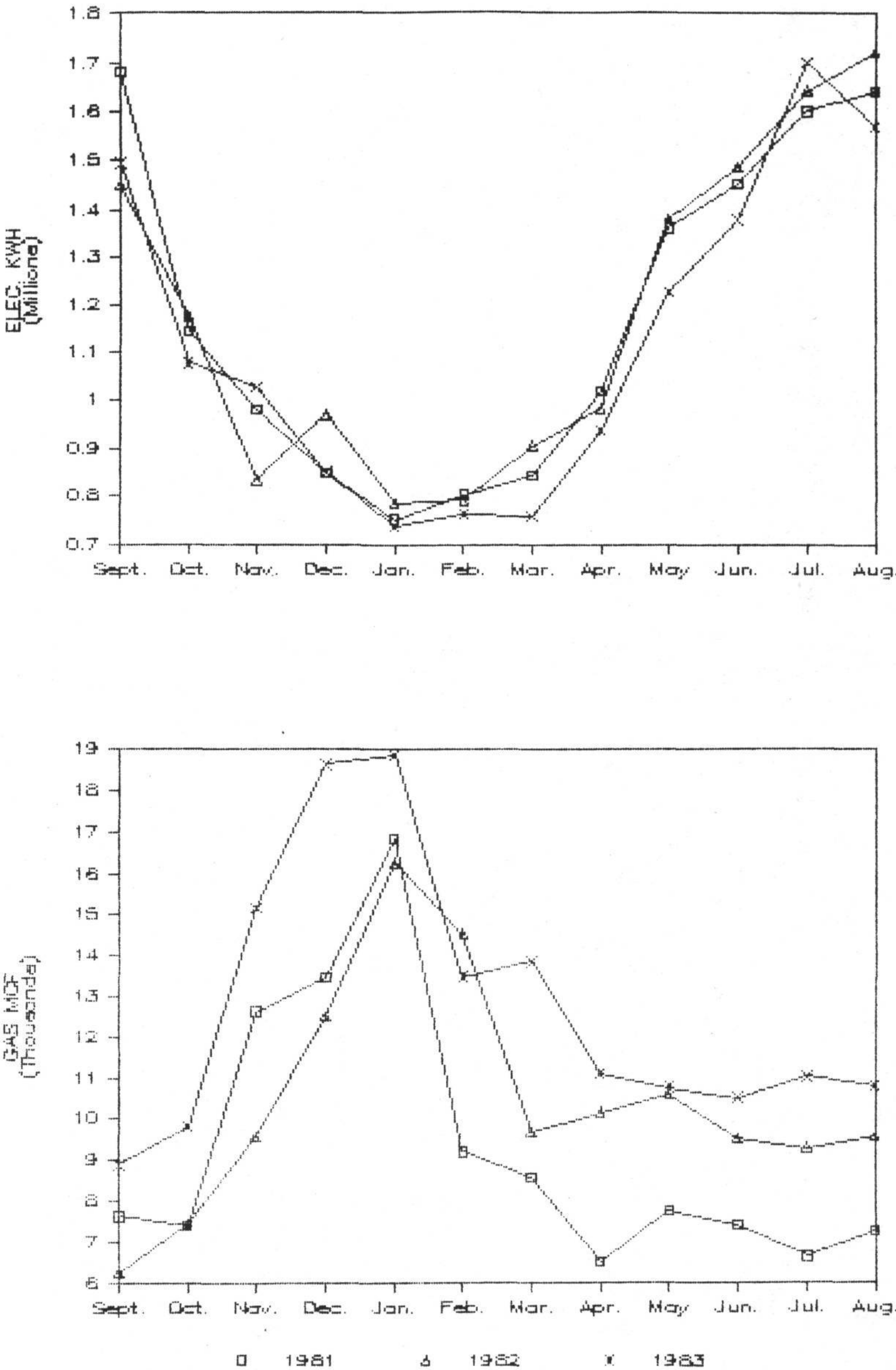


Figure C-5



ELEC. KWH
(Millions)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF
(Thousands)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
1981
1982
1983

Figure C-6

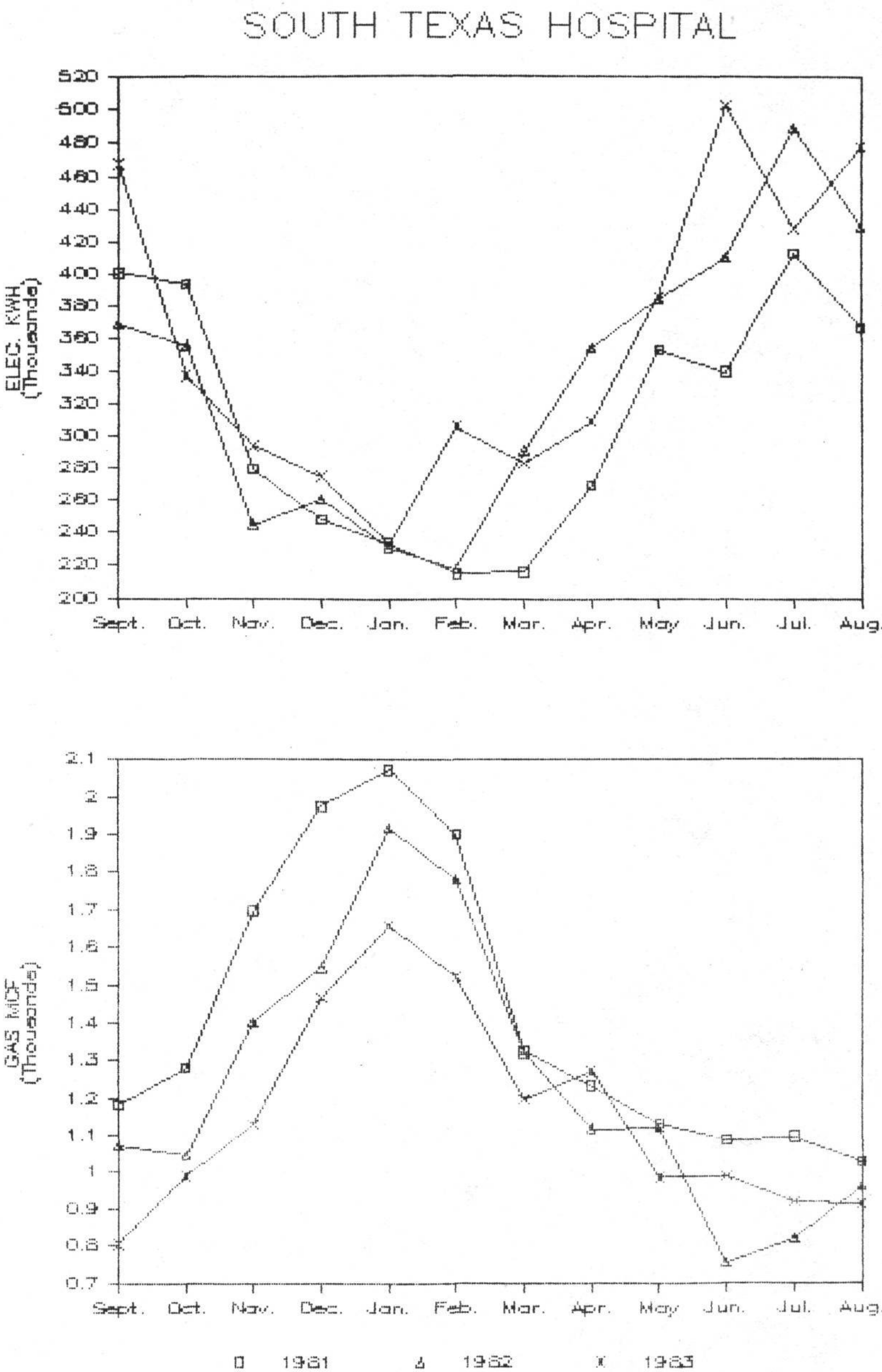
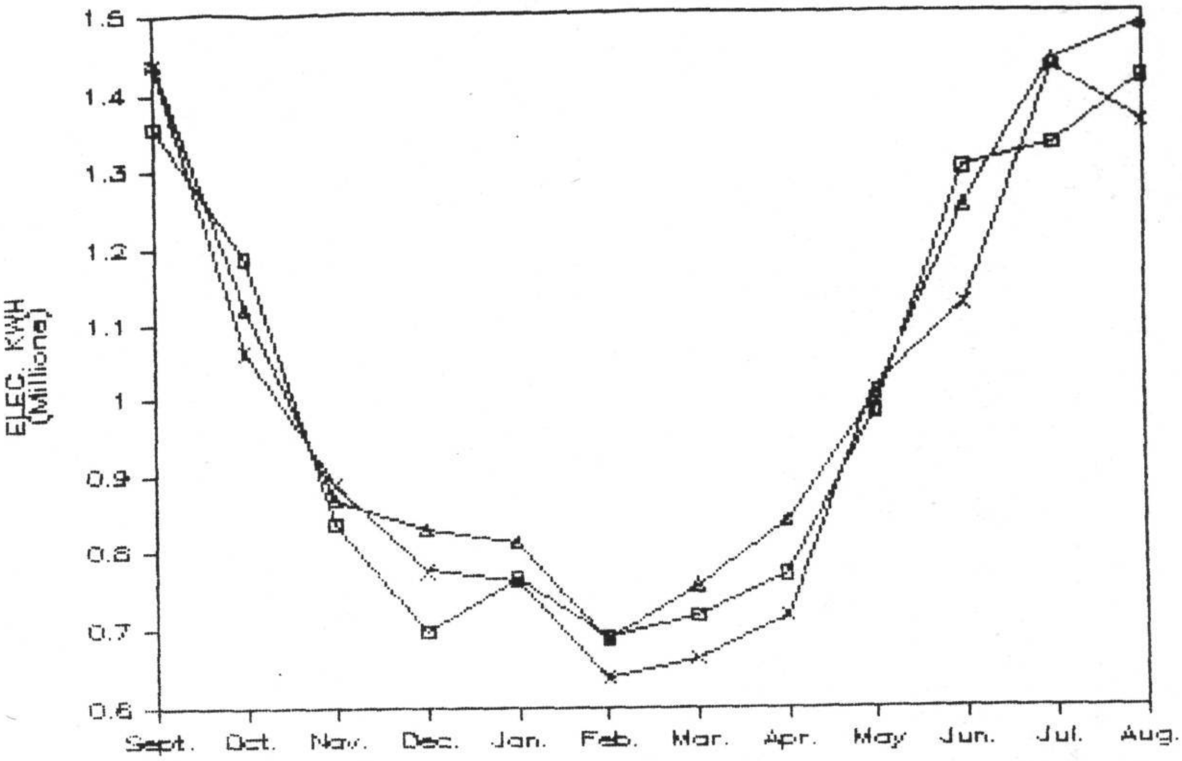

SOUTH TEXAS HOSPITAL
ELEC. KWH (Thousands)
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
GAS MCF (Thousands)
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
1981
1982
1983

Figure C-7

SAN ANTONIO STATE HOSPITAL



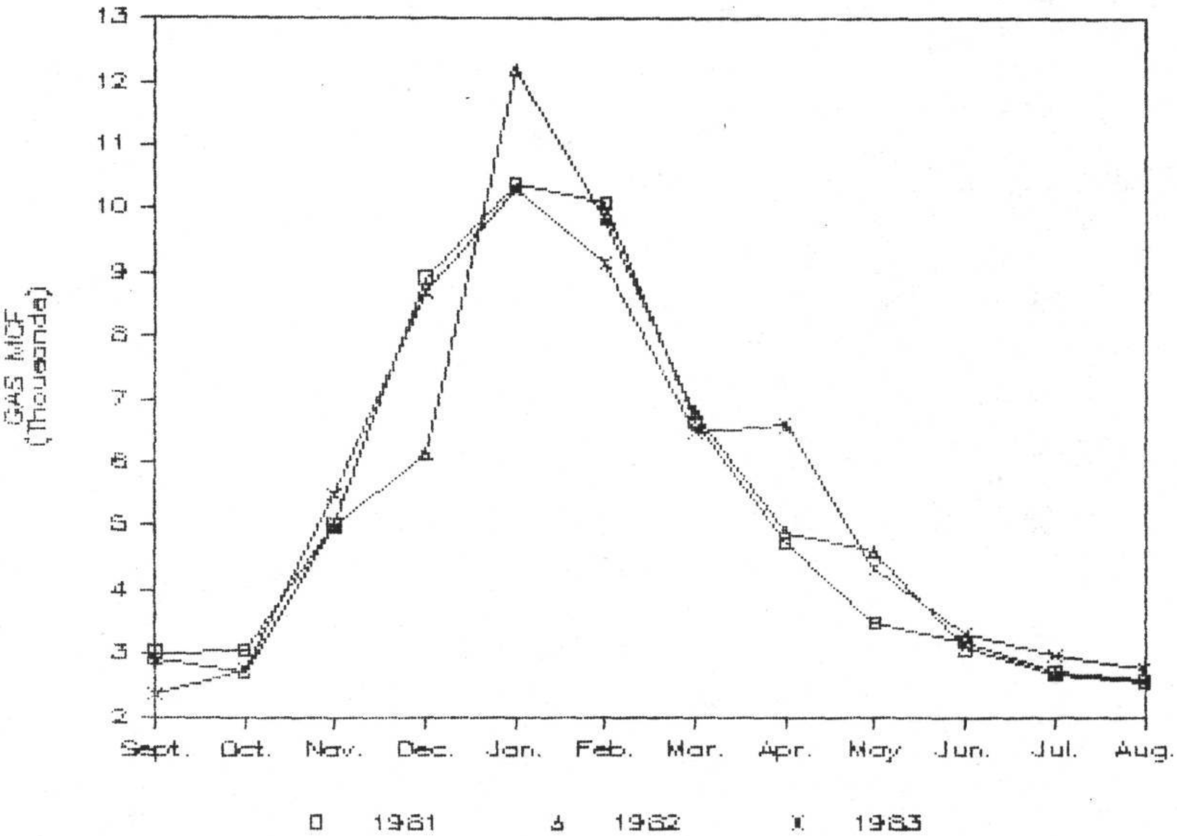


Figure C-8

TEXAS TECH HEALTH SC. CENTER

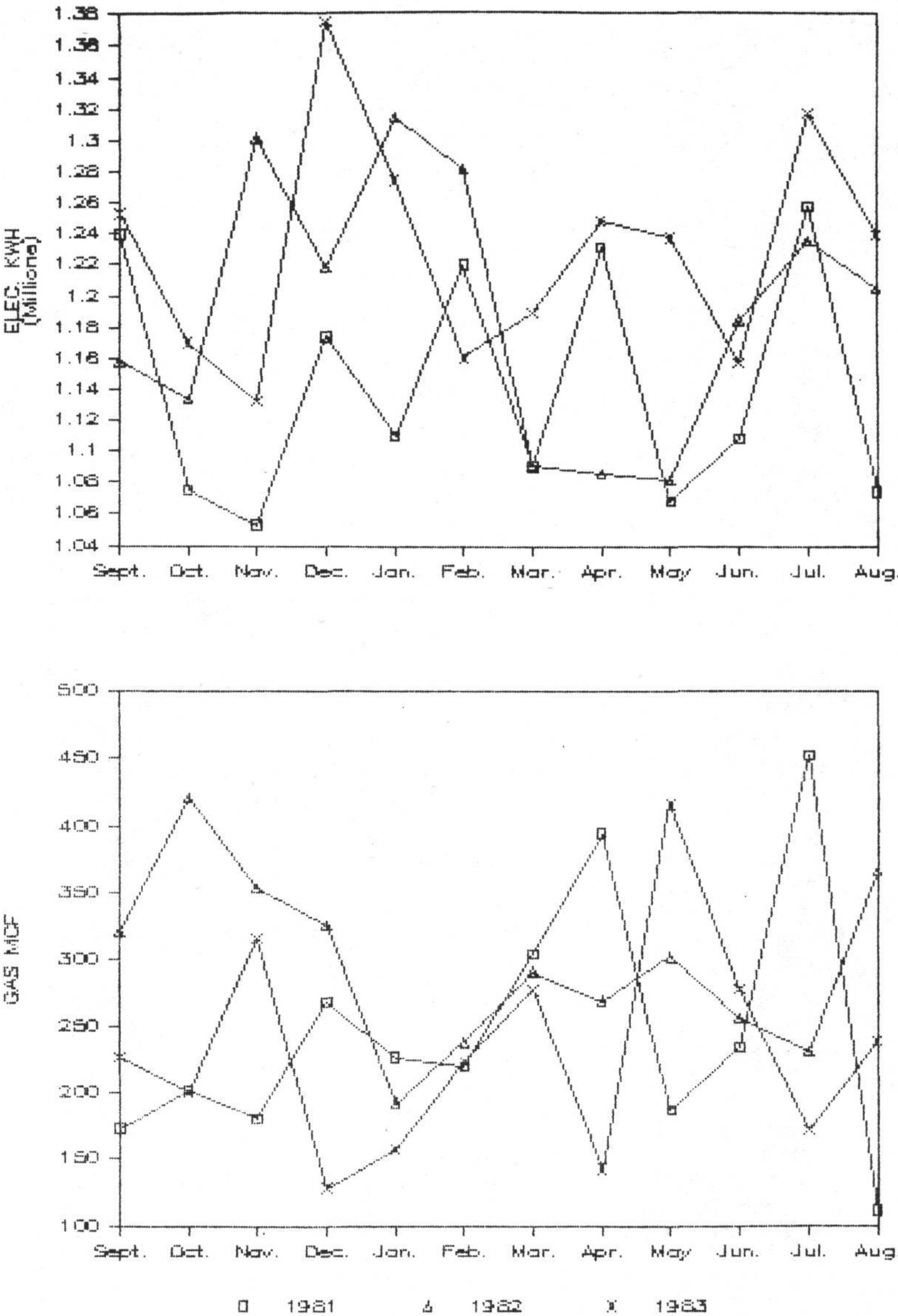
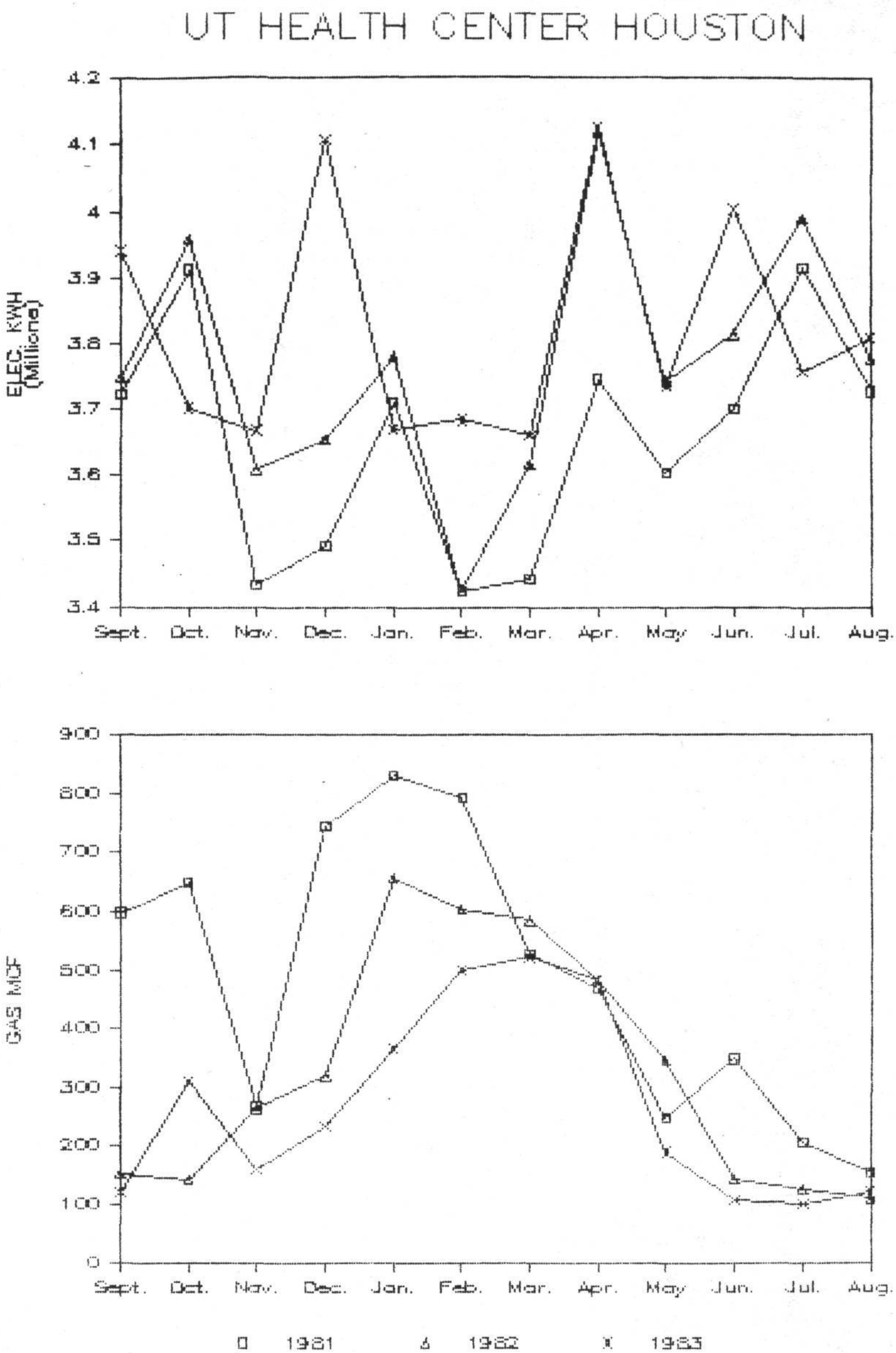


Figure C-9



UT HEALTH CENTER HOUSTON
ELEC. KWH (Millions)
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
GAS MCF
900
800
700
600
500
400
300
200
100
0
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
□ 1981 △ 1982 X 1983

Figure C-10

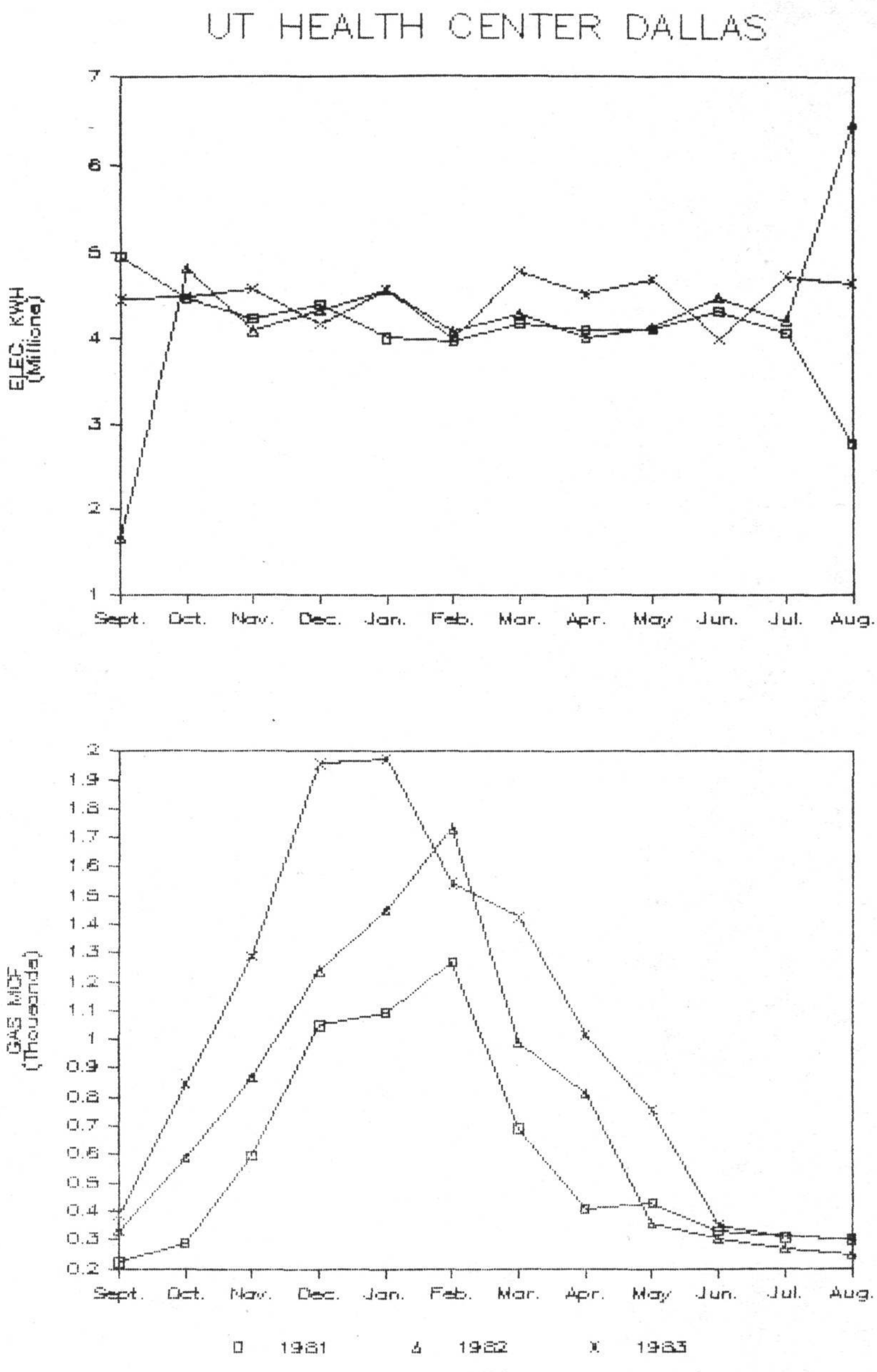
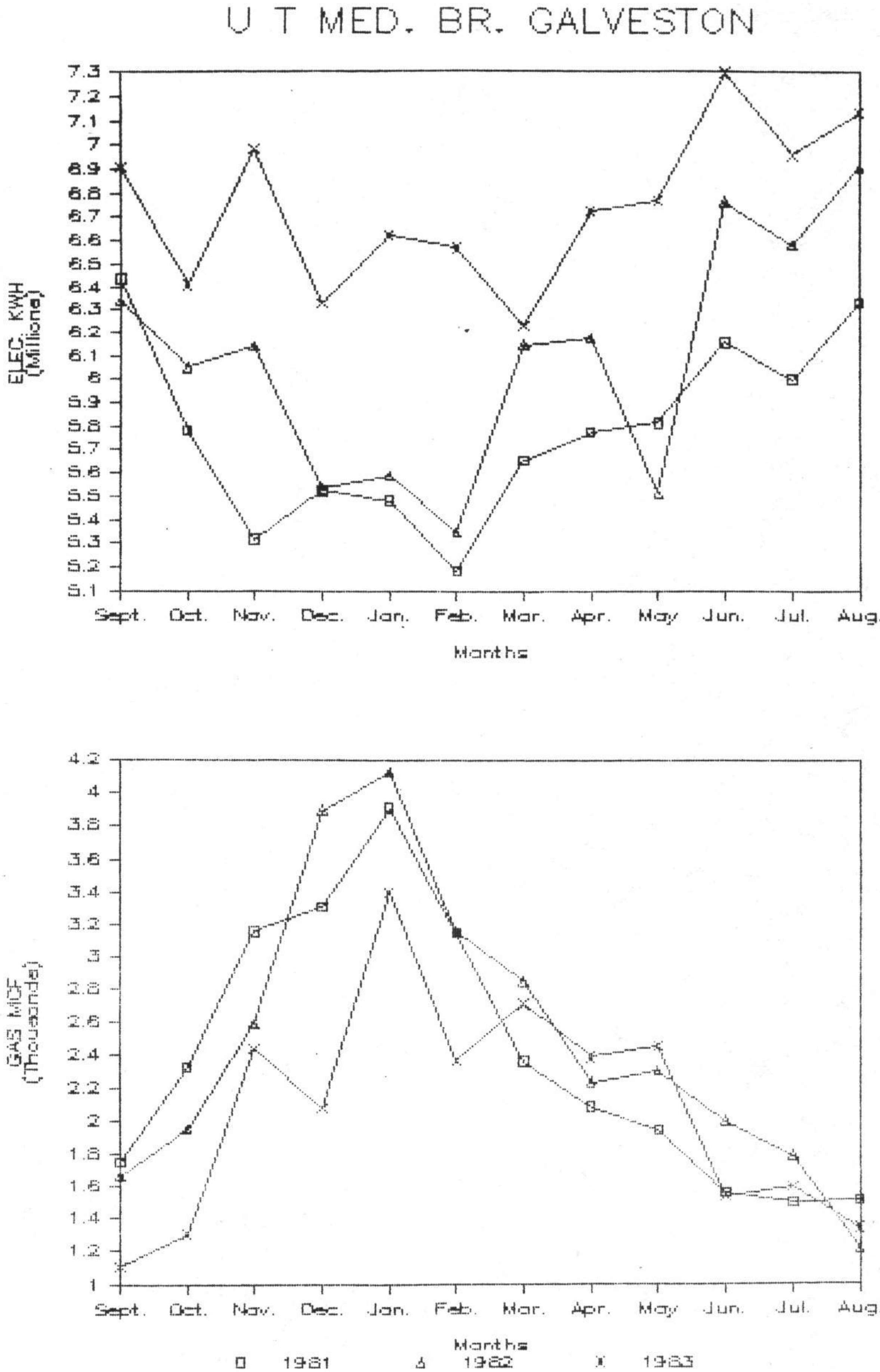

UT HEALTH CENTER DALLAS
ELEC. KWH (Millions)
7
6
5
4
3
2
1
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1981
1982
1983

Figure C-11



U T MED. BR. GALVESTON
ELEC. KWH (Millions)
7.3
7.2
7.1
7
6.9
6.8
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7
5.6
5.5
5.4
5.3
5.2
5.1
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Months
GAS MCF (Thousands)
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Months
1981
1982
1983

Figure C-12

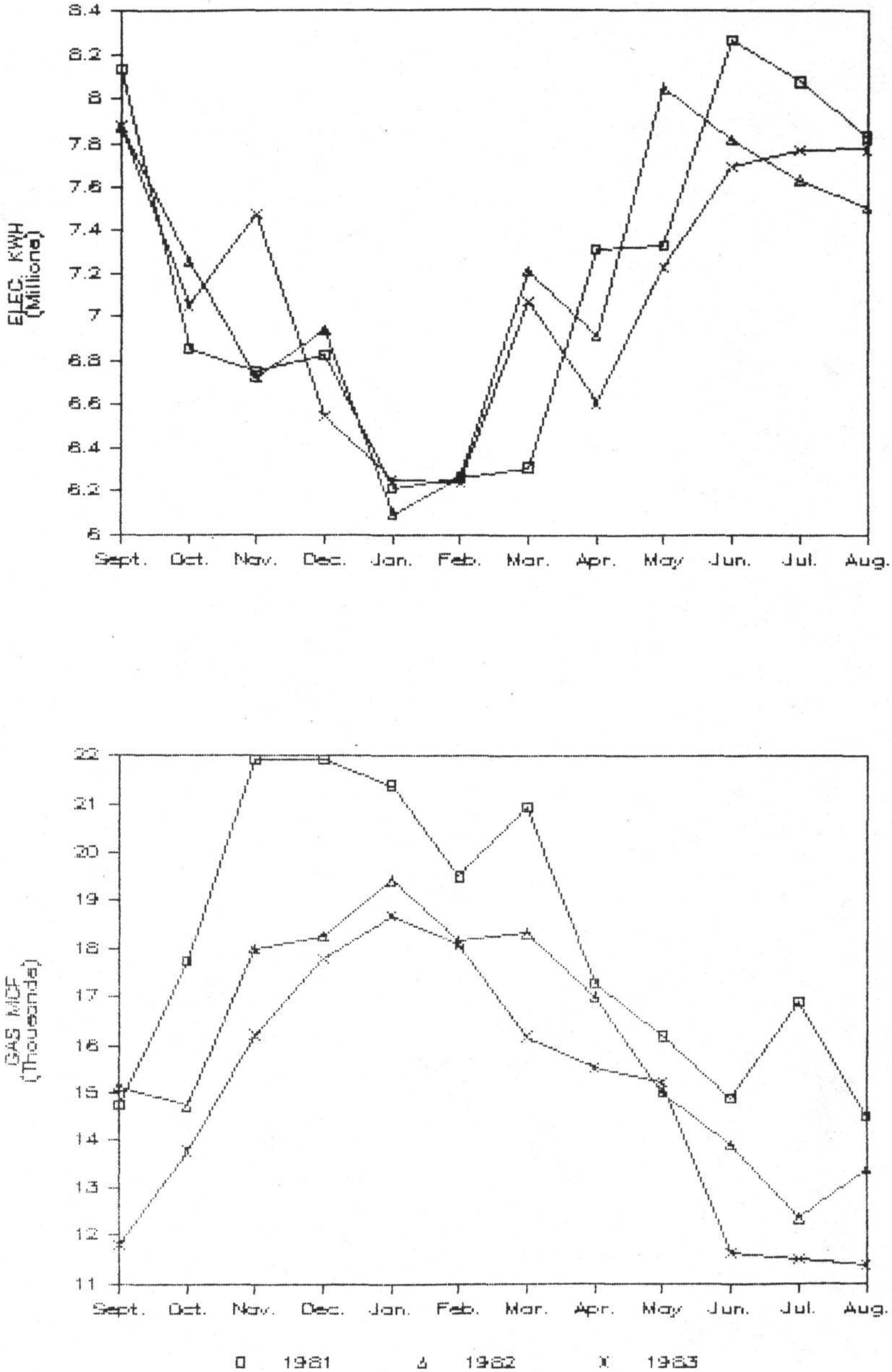
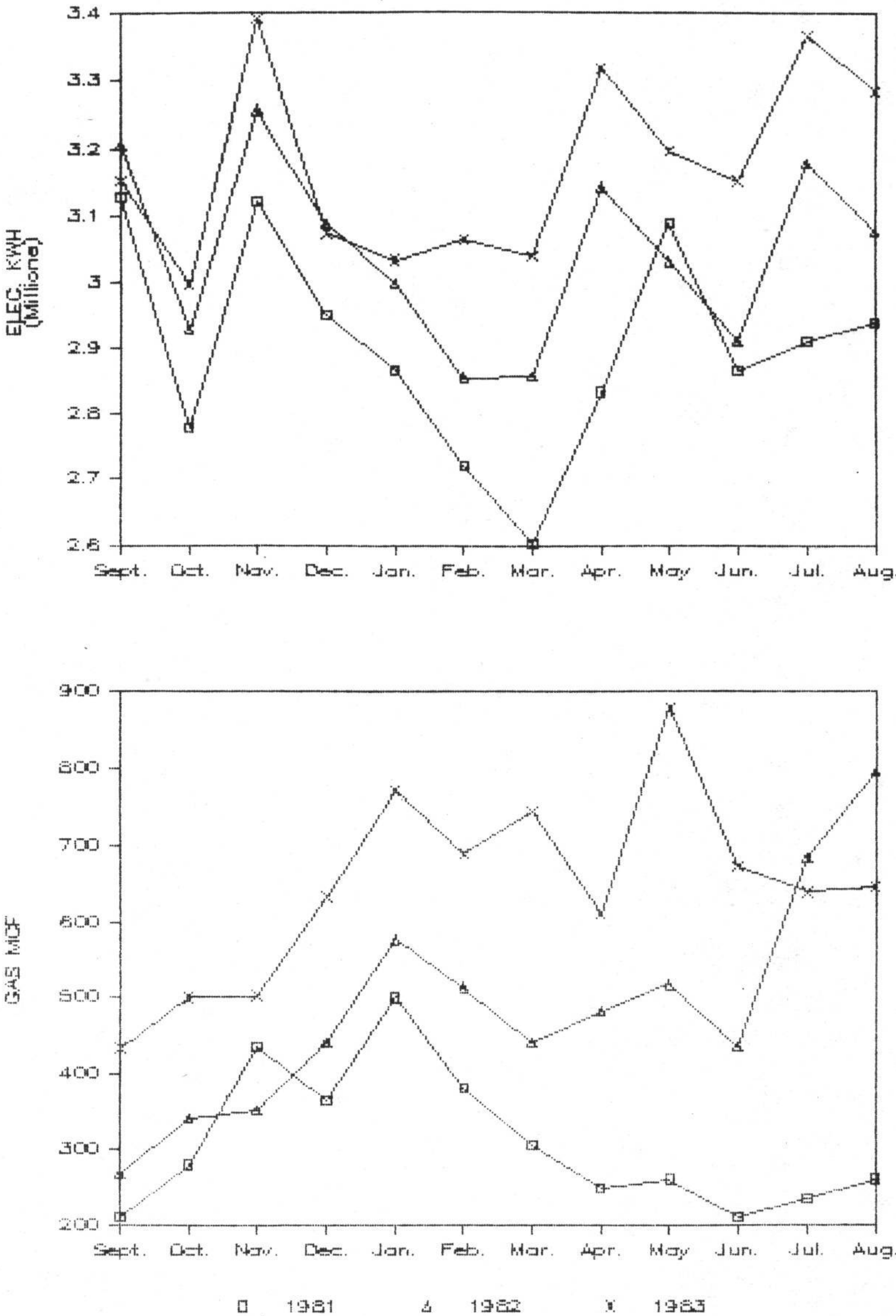

8.4
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
ELEC. KWH (Millions)
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
22
21
20
19
18
17
16
15
14
13
12
11
GAS MCF (Thousands)
1981
1982
1983

Figure C-13



3.4
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
ELEC. KWH (Millions)
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
900
800
700
600
500
400
300
200
GAS MCF
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
1981
1982
1983

Figure C-14

TEXAS A&M UNIVERSITY

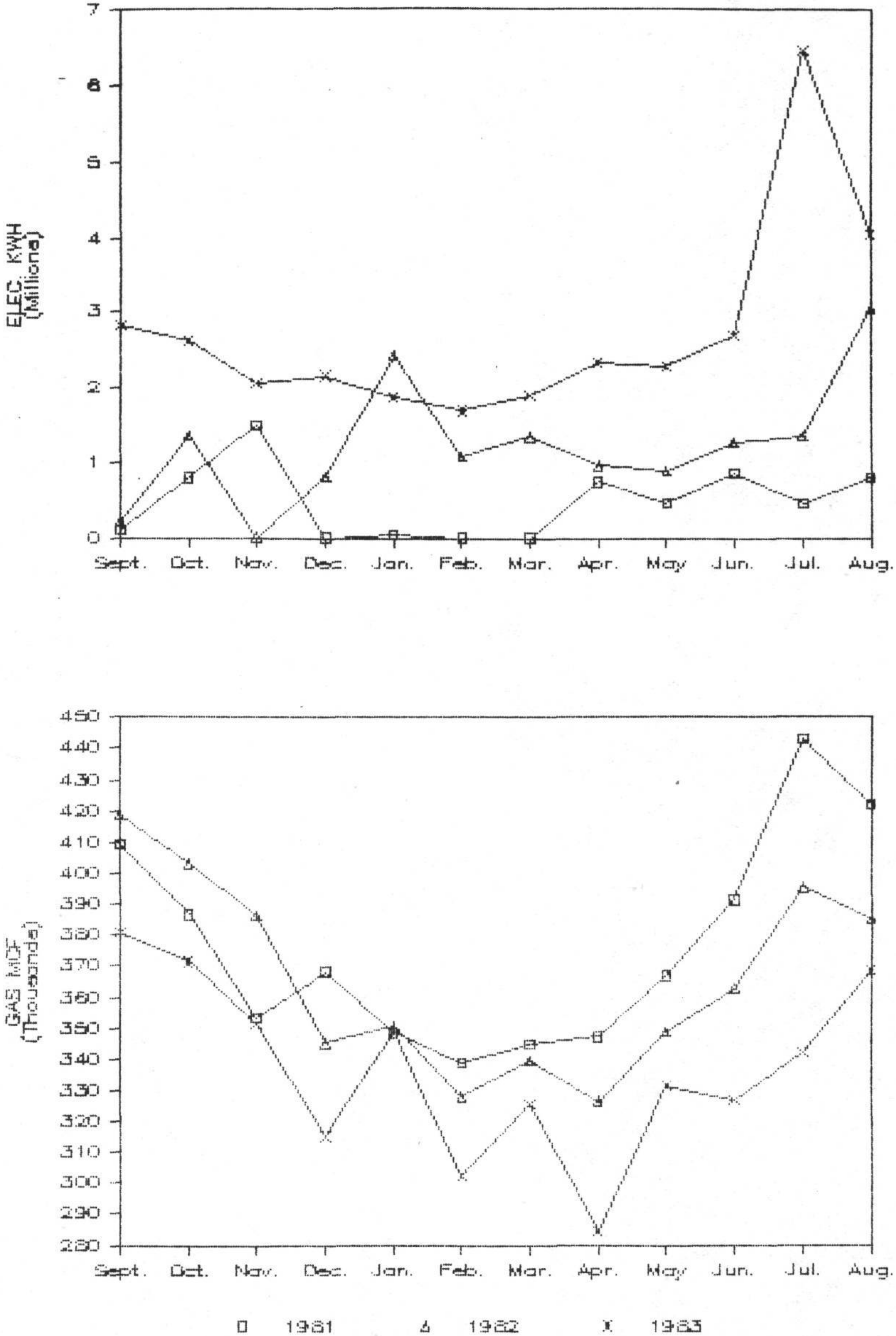


Figure C-15

UNIV. OF TEXAS AUSTIN

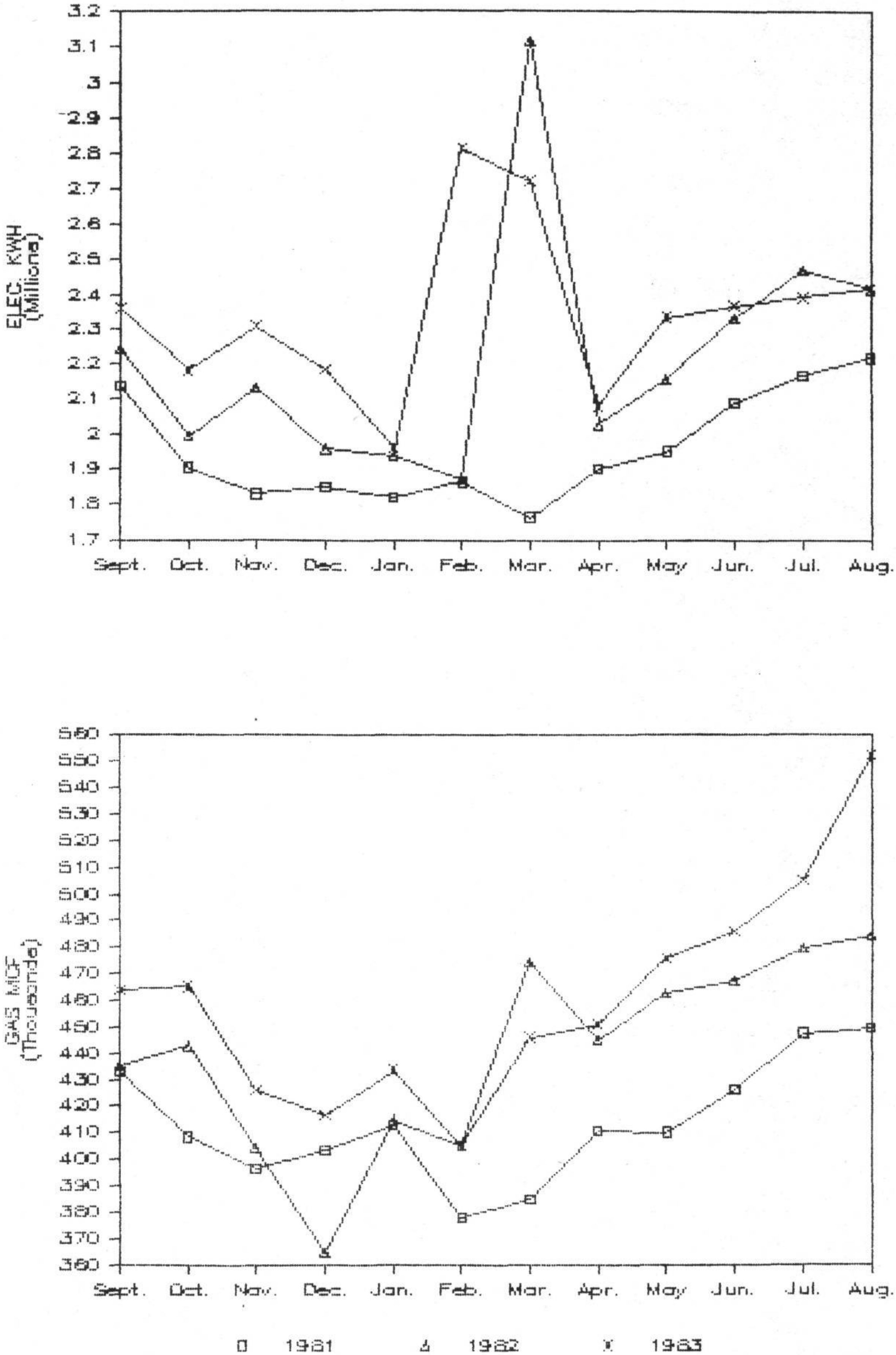


Figure C-16

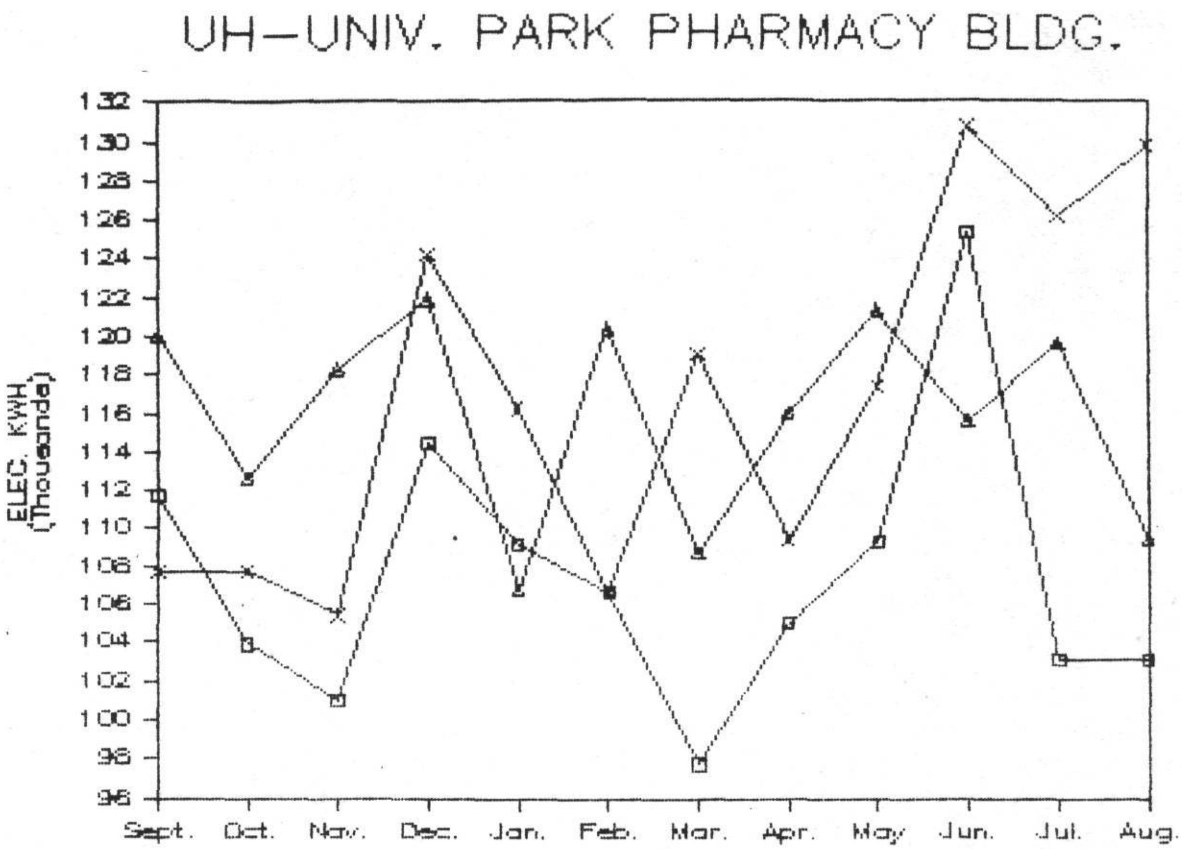

UH–UNIV. PARK PHARMACY BLDG.
ELEC. KWH
(Thousands)
132
130
128
126
124
122
120
118
116
114
112
110
108
106
104
102
100
98
96
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.

Figure C-17

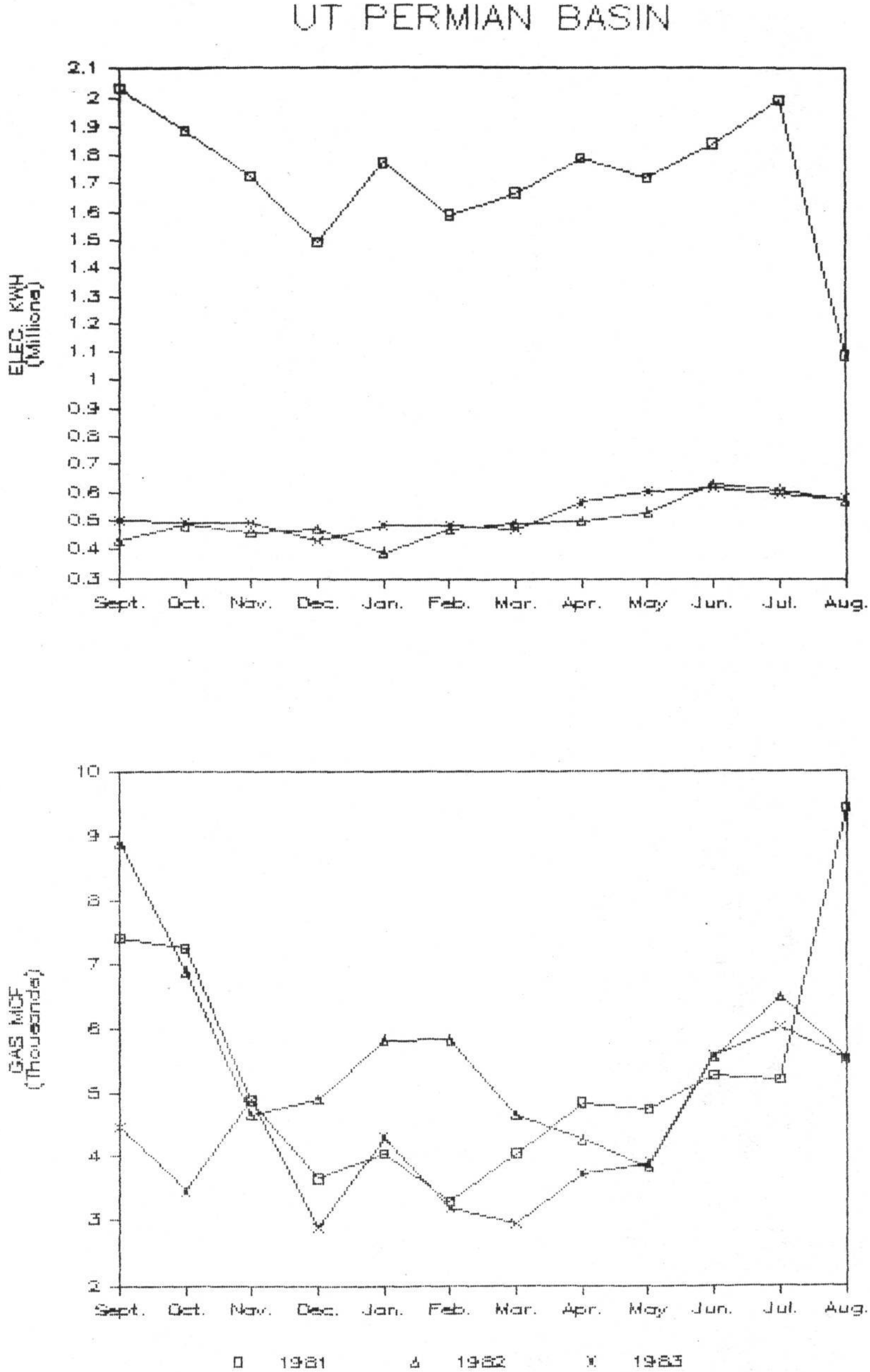

UT PERMIAN BASIN
ELEC. KWH (Millions)
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
10
9
8
7
6
5
4
3
2
□ 1981
△ 1982
X 1983

Figure C-18

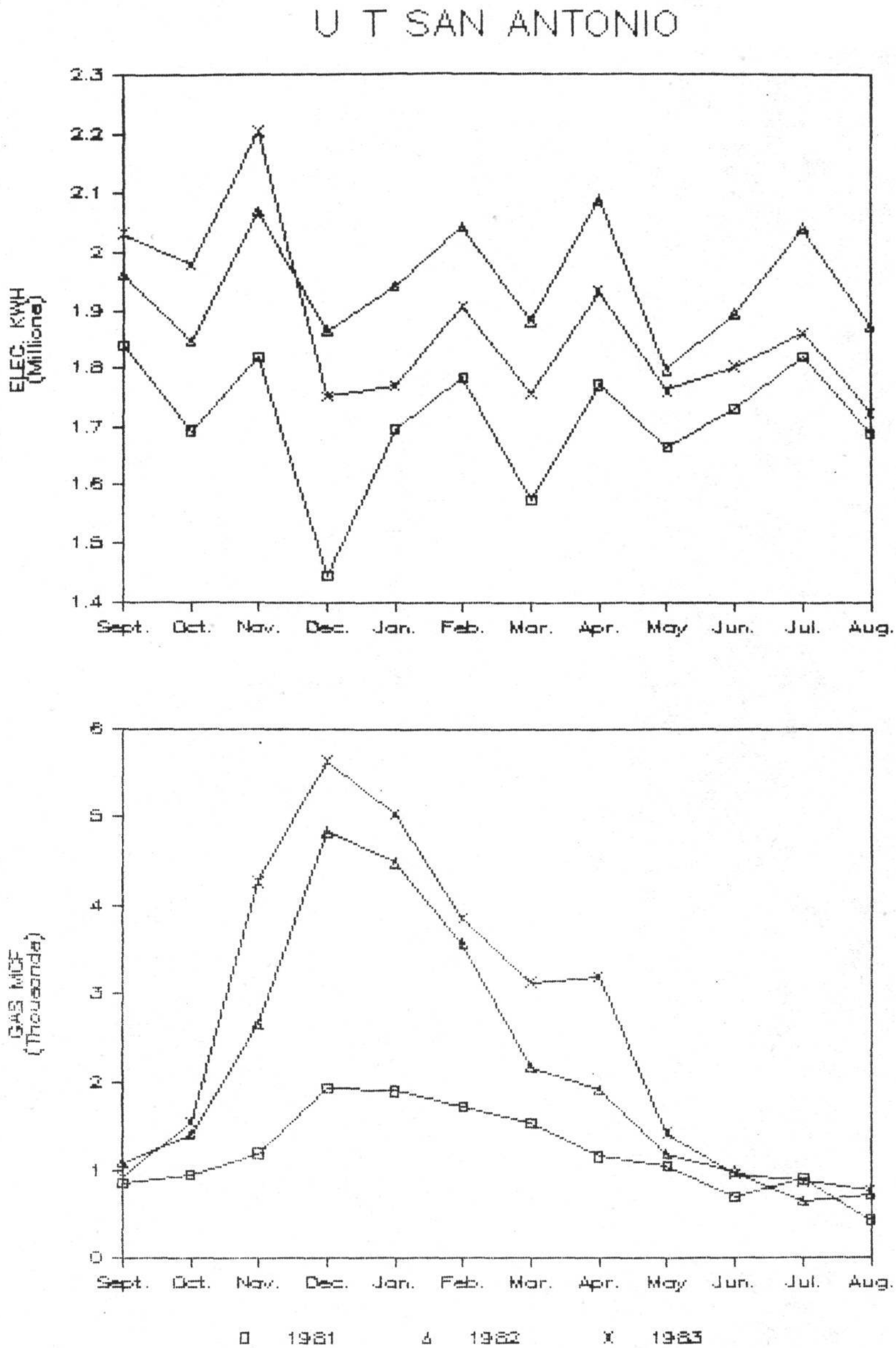

U T SAN ANTONIO
ELEC. KWH
(Millions)
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF
(Thousands)
6
5
4
3
2
1
0
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
1981
1982
1983

Figure C-19

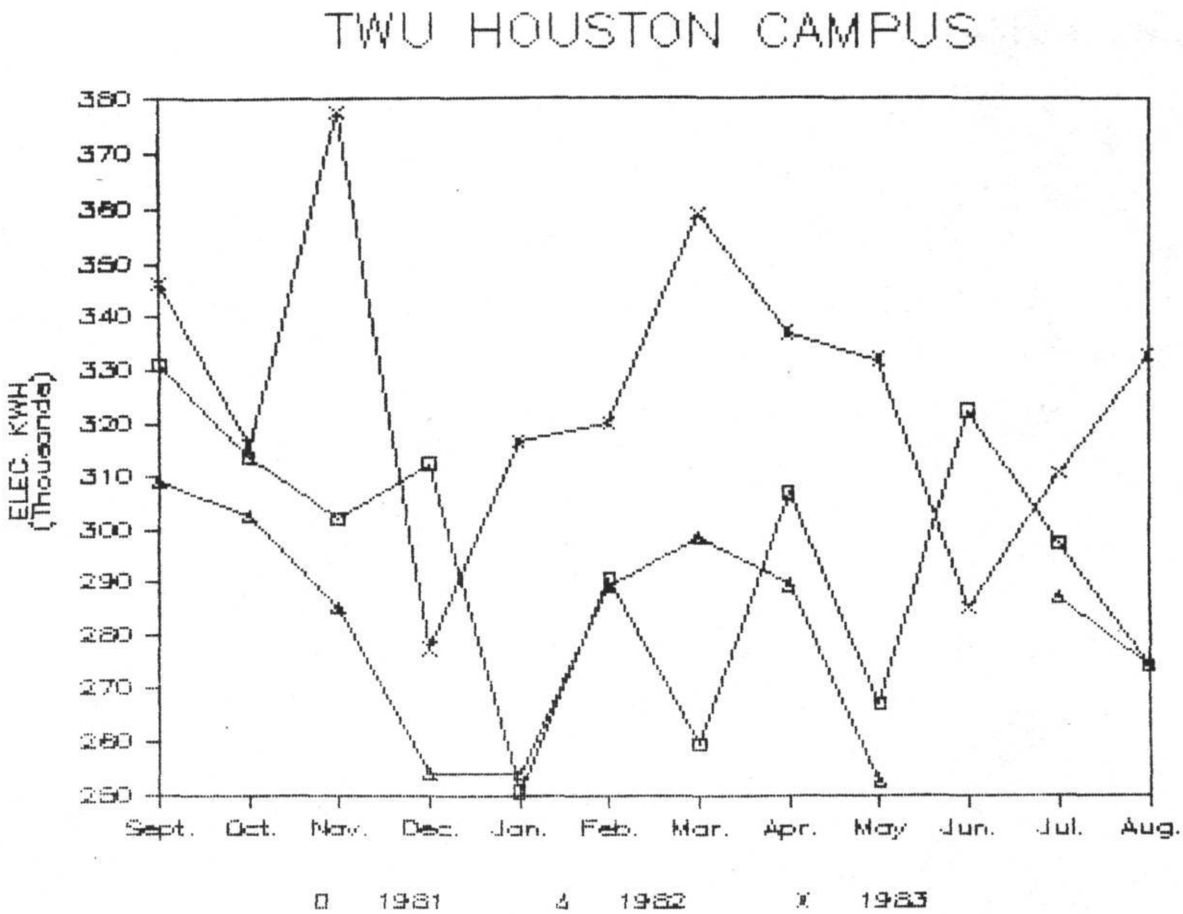
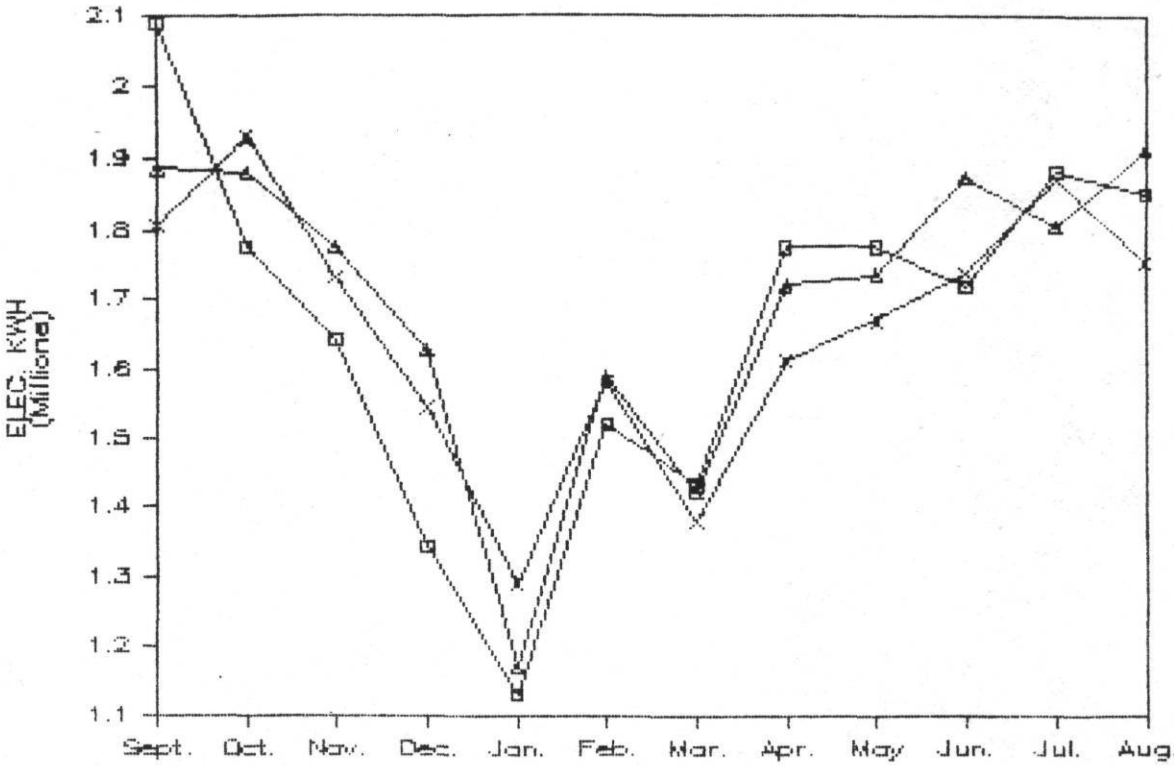
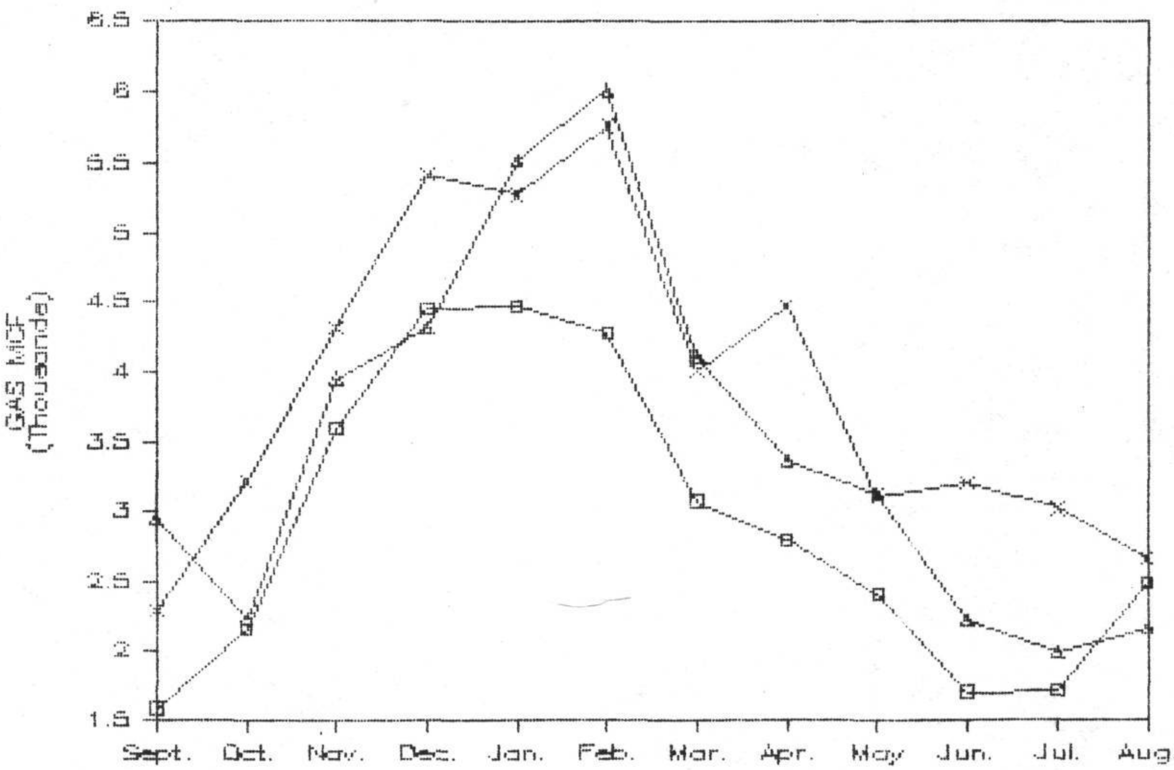

TWU HOUSTON CAMPUS
ELEC. KWH (Thousands)
380
370
360
350
340
330
320
310
300
290
280
270
260
250
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
1981
1982
1983

Figure C-20

PAN AMERICAN UNIV.





□ 1981 △ 1982 X 1983

Figure C-21

U T DALLAS

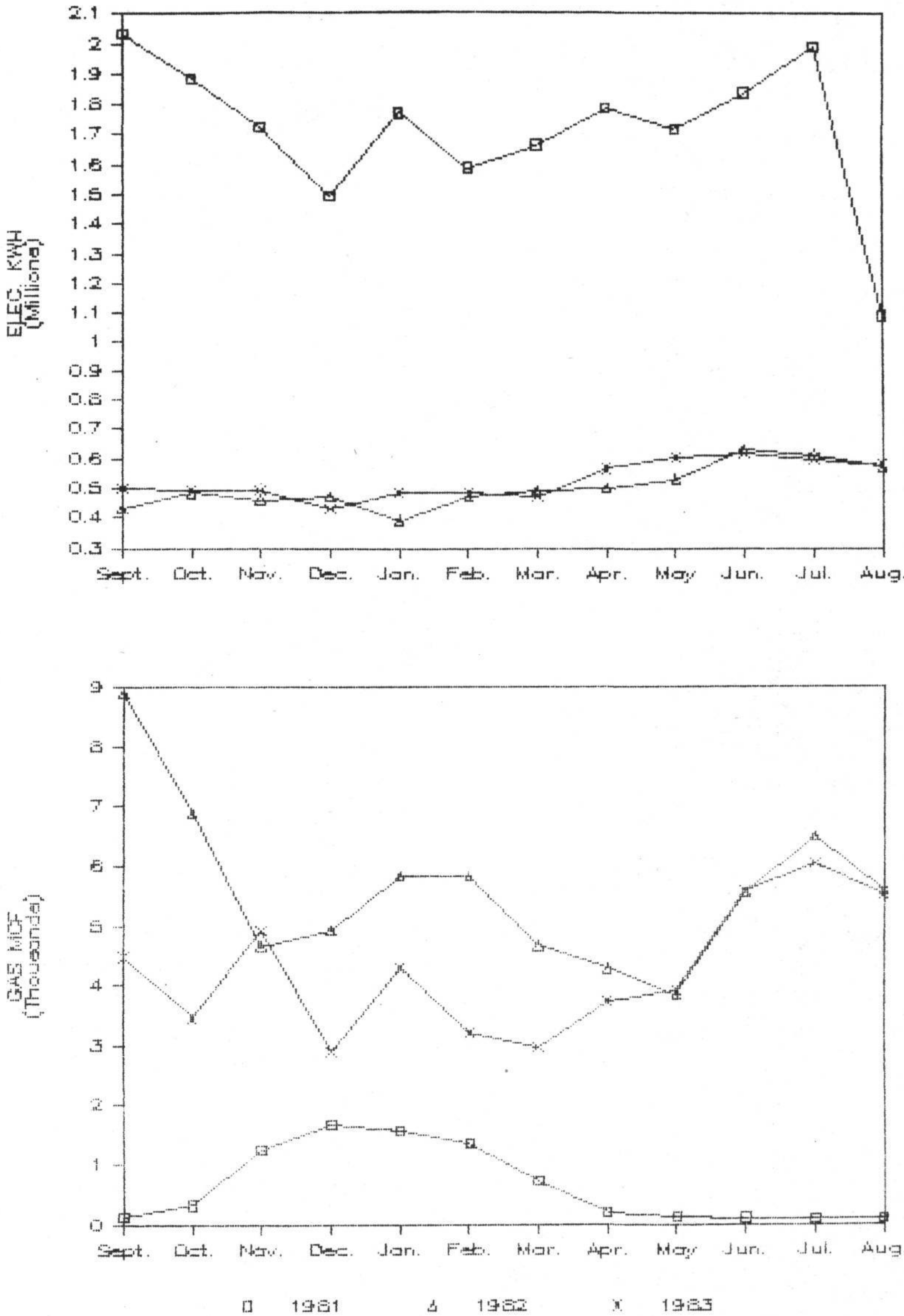


Figure C-22

TEXAS TECH UNIVERSITY

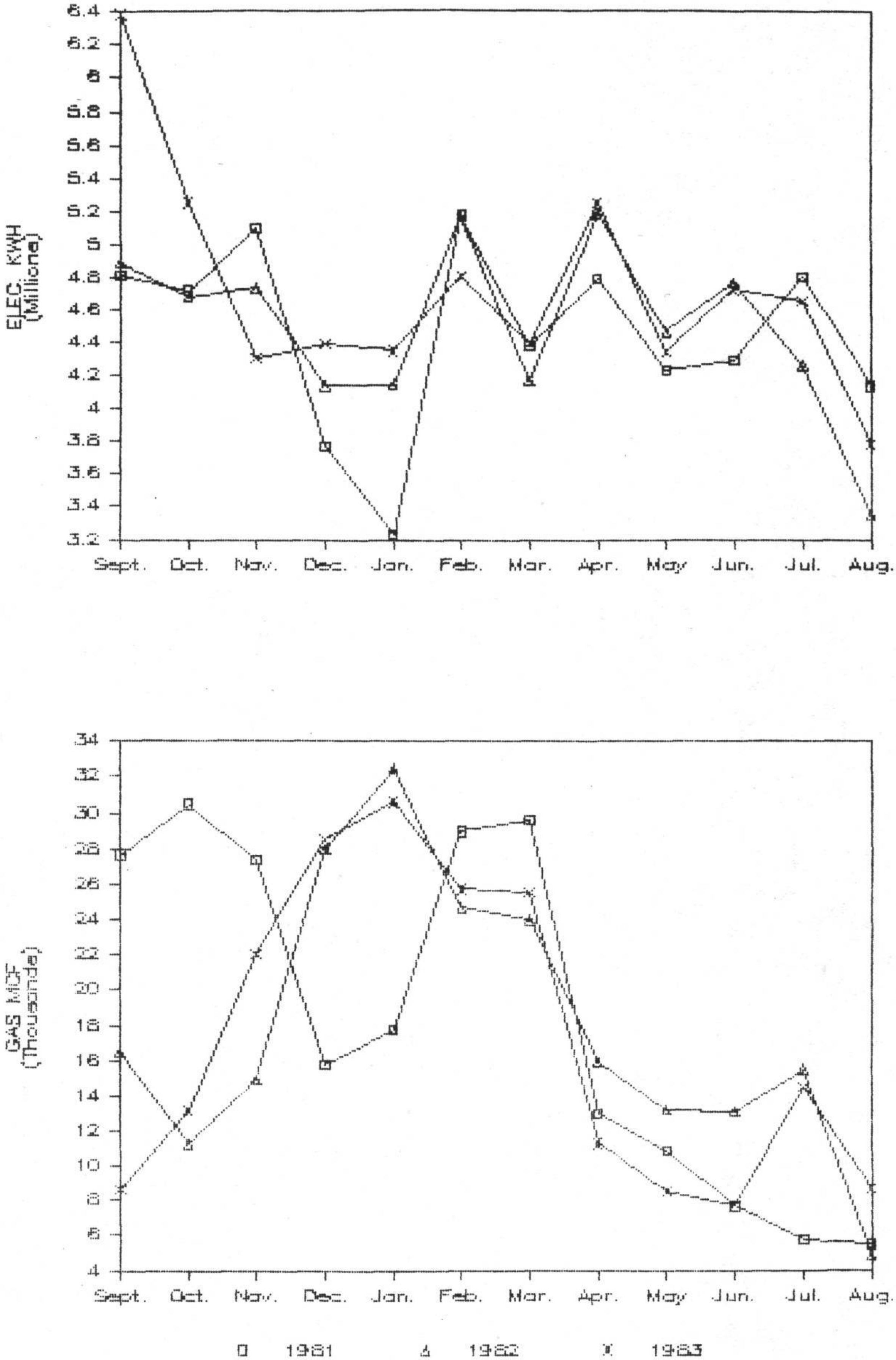


Figure C-23

U T EL PASO

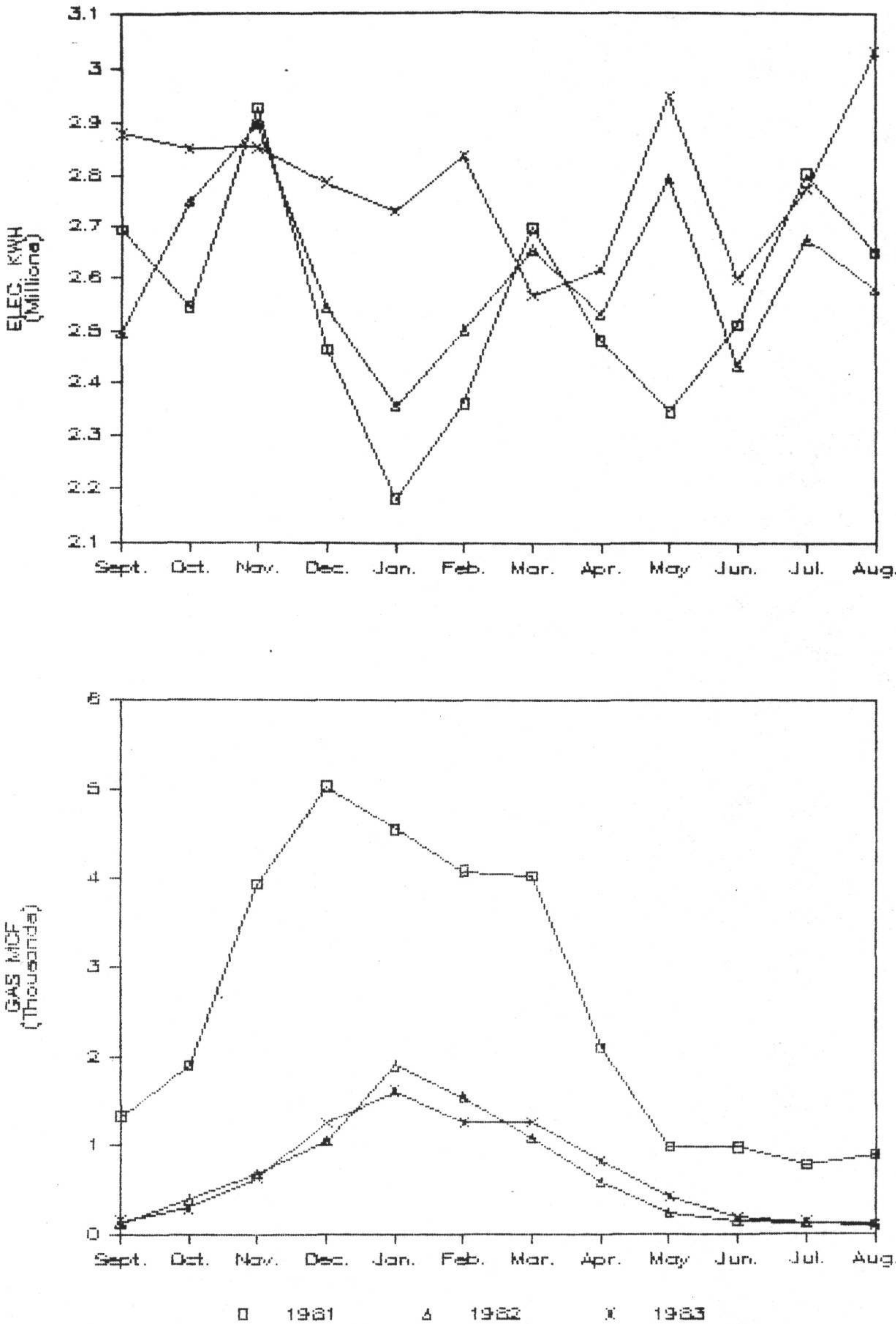


Figure C-24

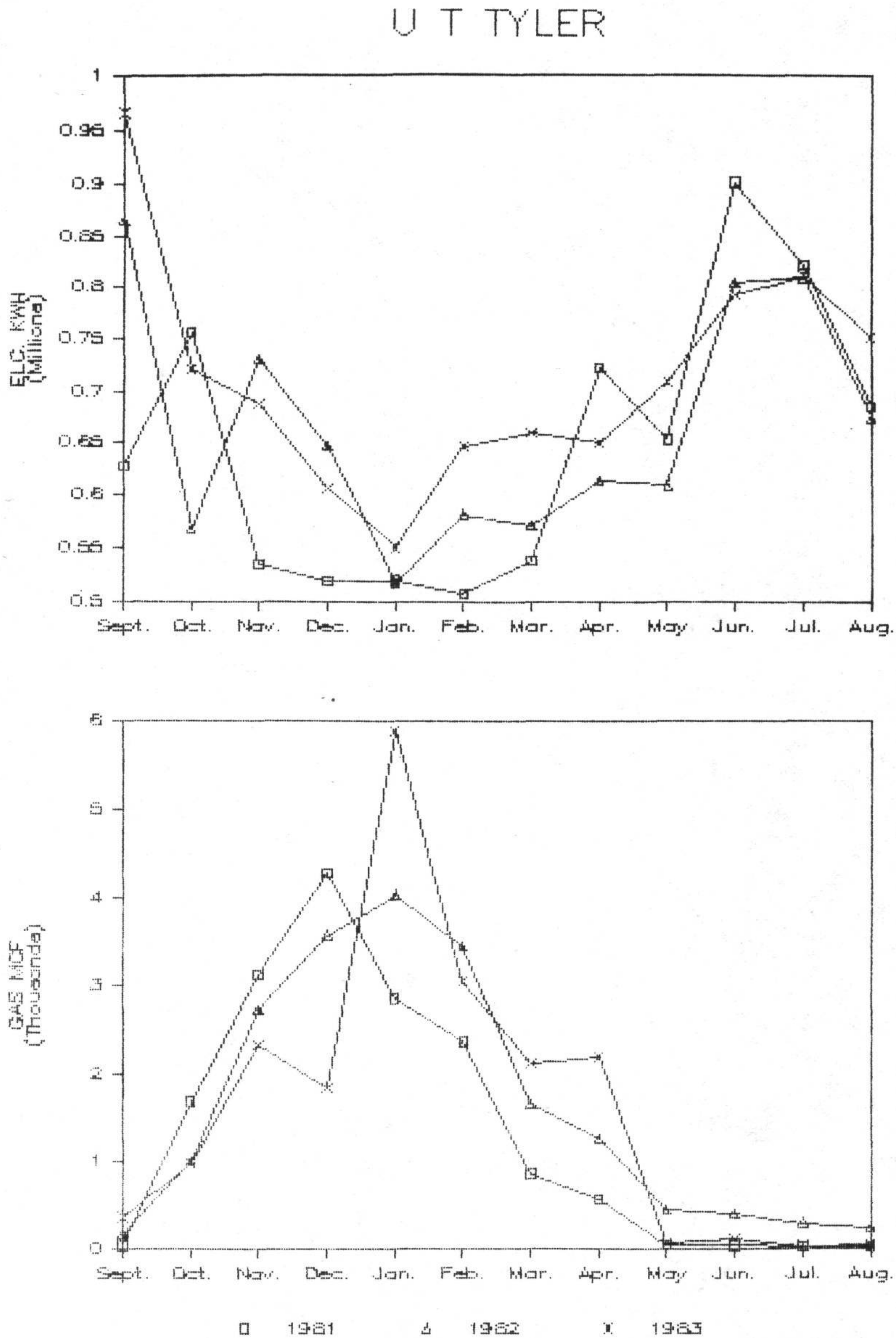

U T TYLER
ELC. KWH (Millions)
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
6
5
4
3
2
1
0
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
1981
1982
1983

Figure C-25

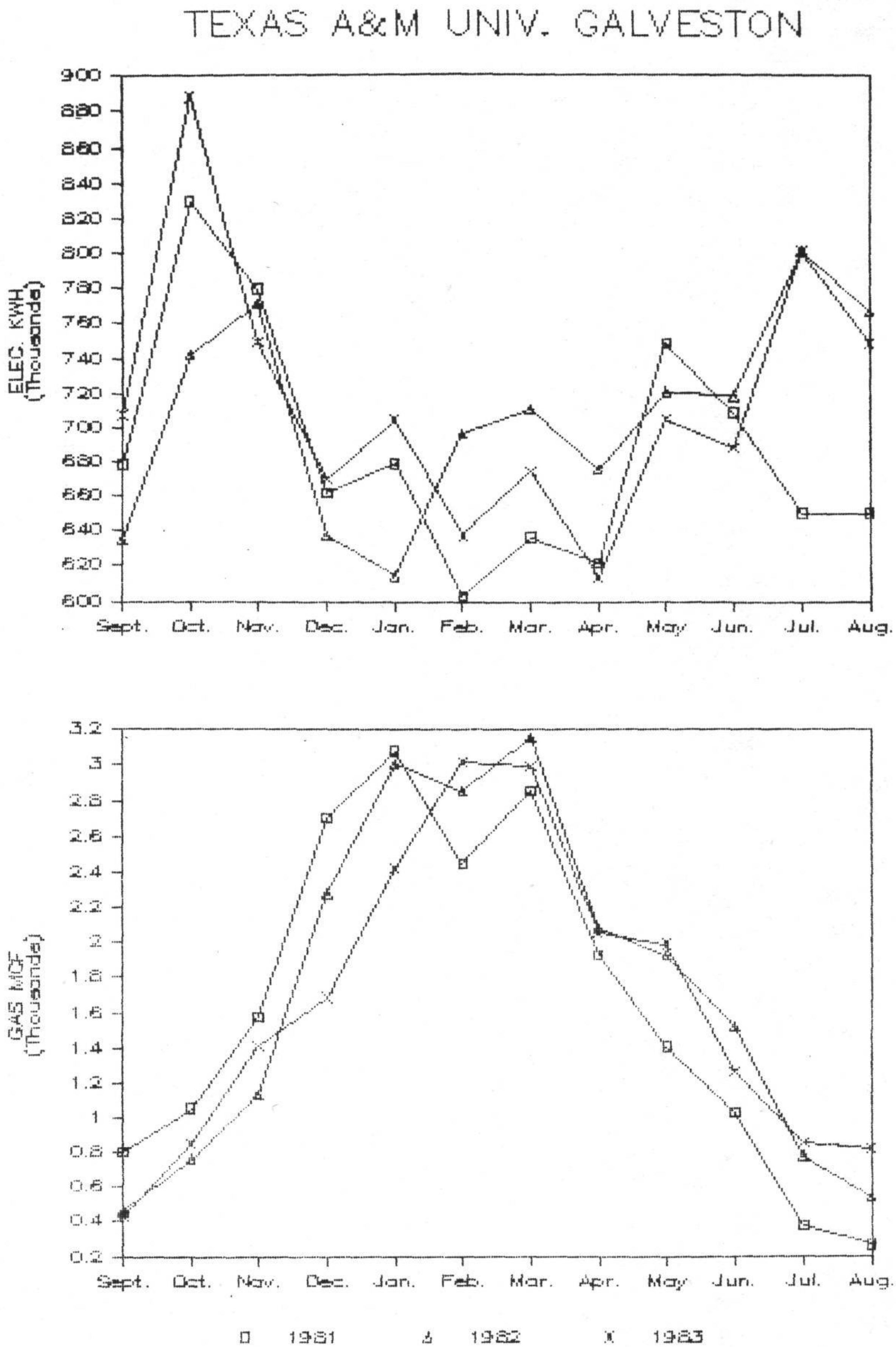

TEXAS A&M UNIV. GALVESTON
ELEC. KWH (Thousands)
900
880
860
840
820
800
780
760
740
720
700
680
660
640
620
600
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
1981
1982
1983

Figure C-26

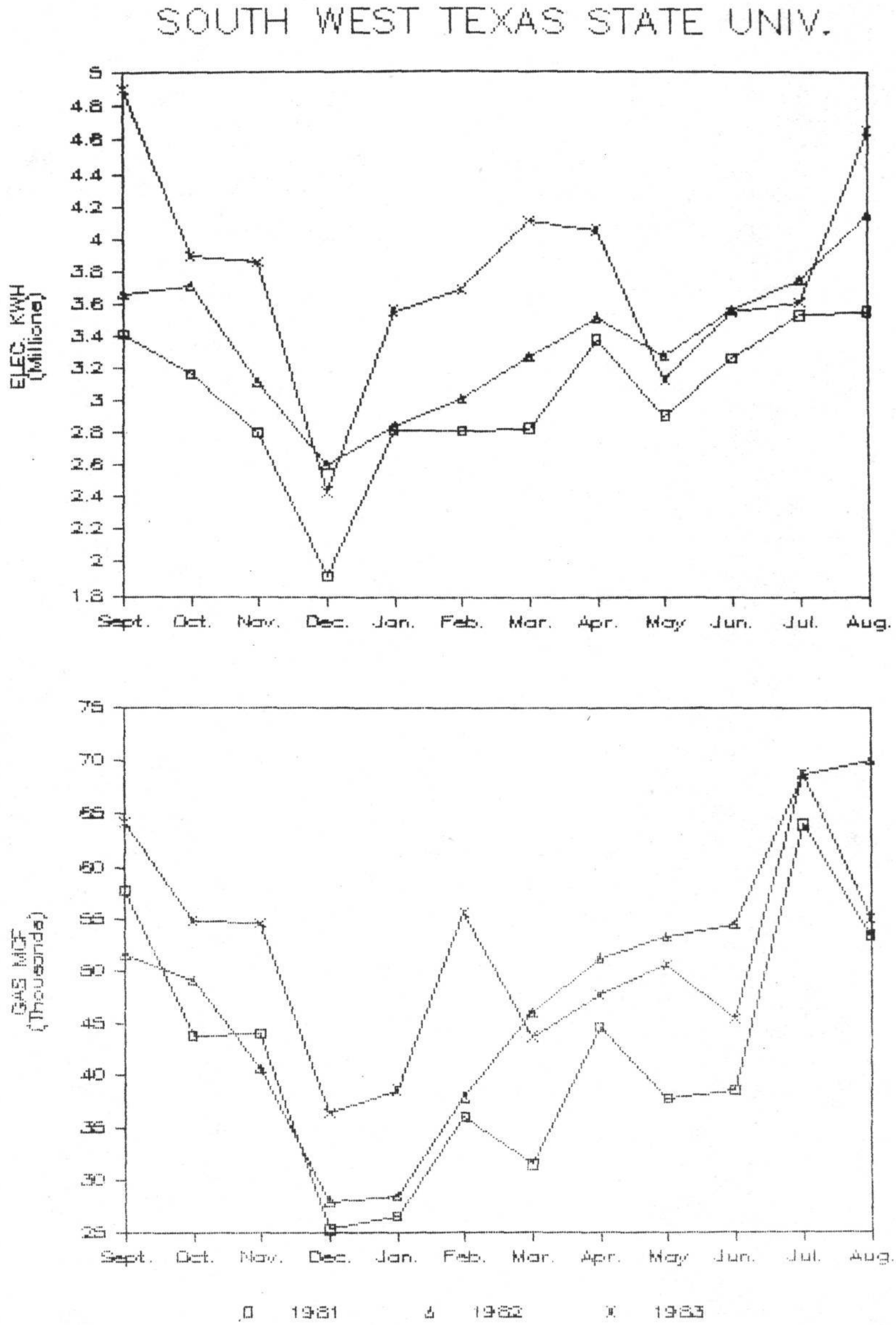
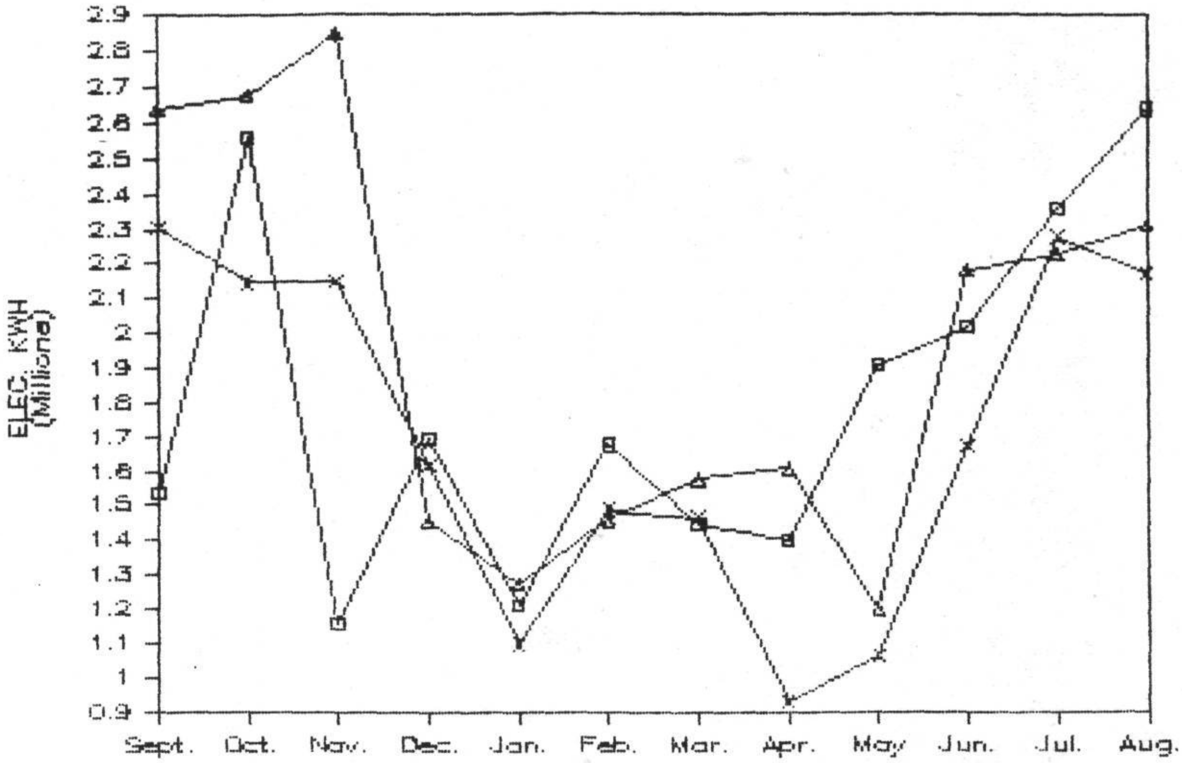

SOUTH WEST TEXAS STATE UNIV.
ELEC. KWH (Millions)
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
75
70
65
60
55
50
45
40
35
30
25
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
1981
1982
1983

Figure C-27

TWU DENTON CAMPUS



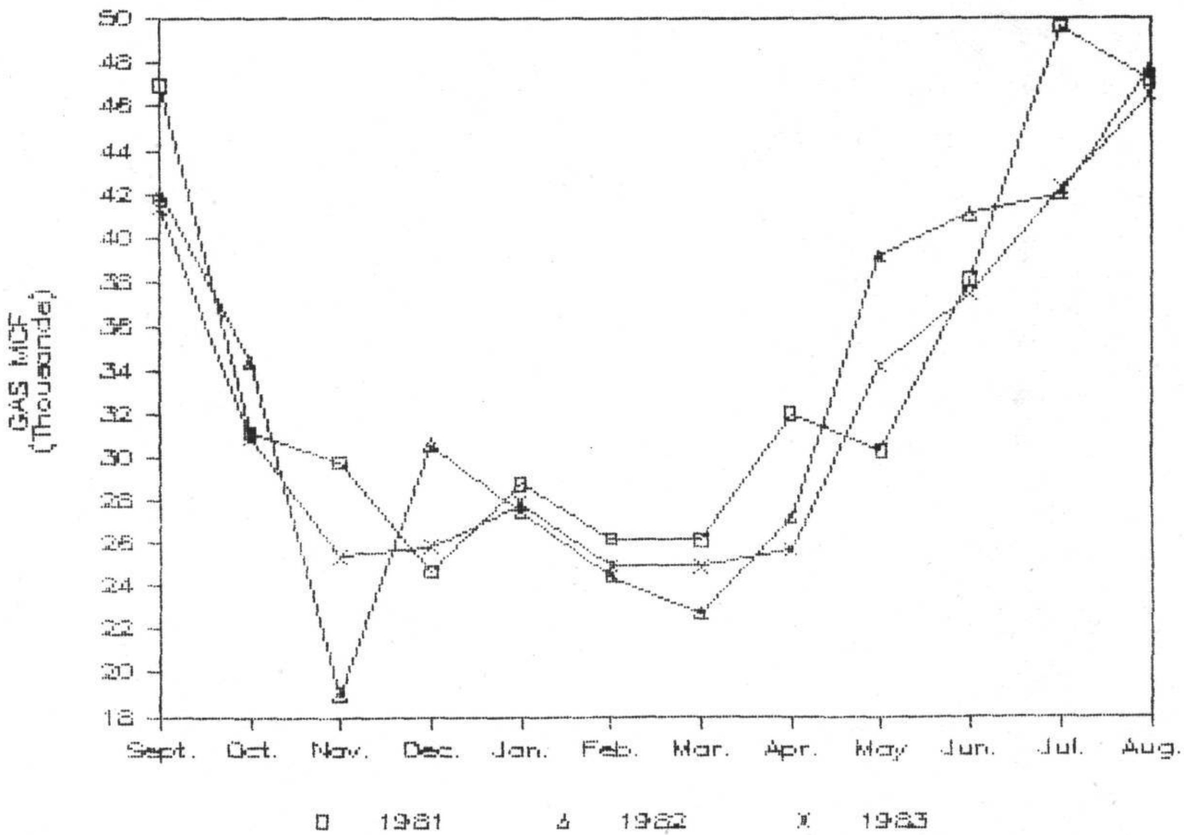


Figure C-28

PRIARIE VIEW A&M UNIVERSITY

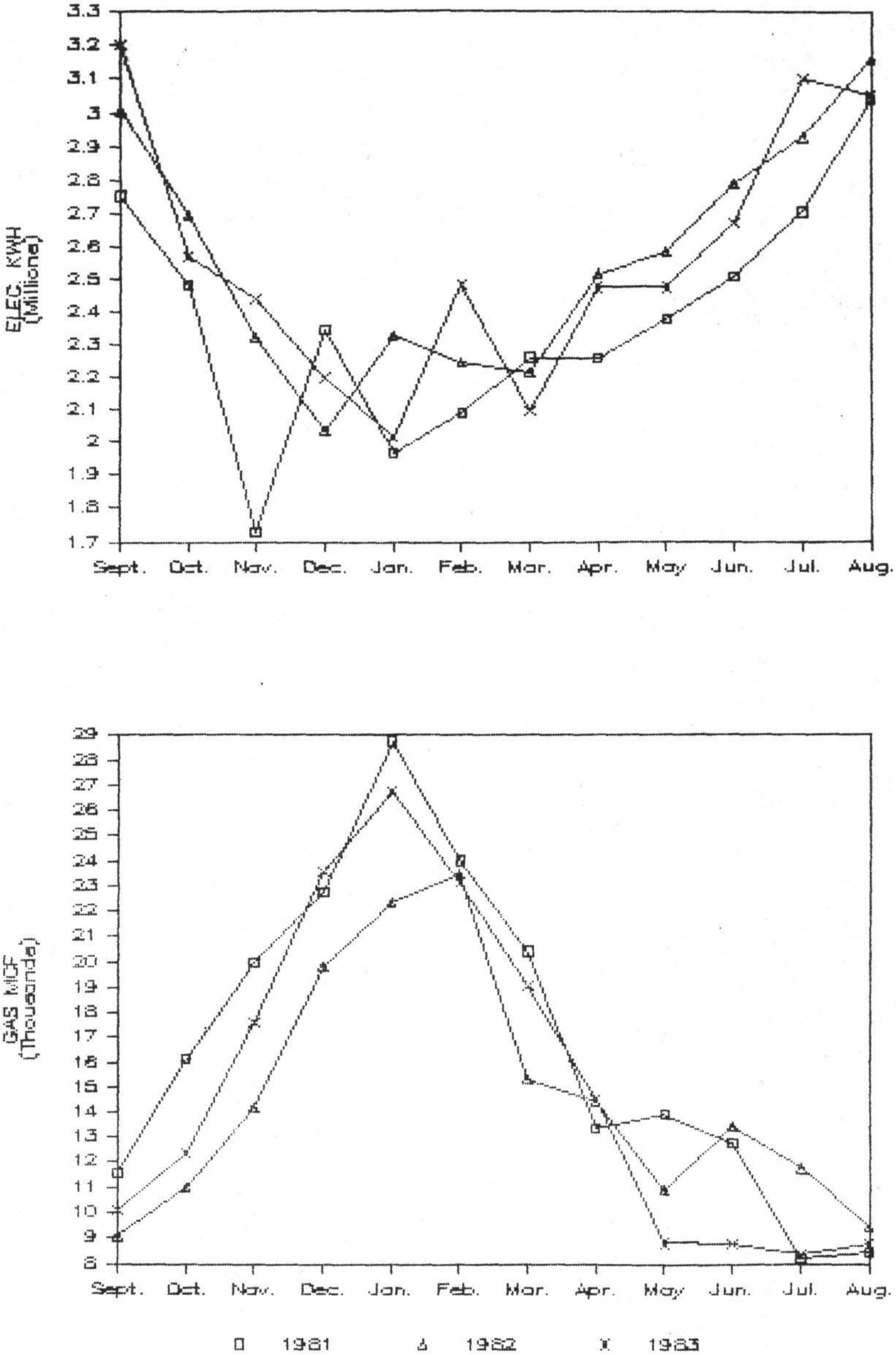


Figure C-29

UNIV. OF HOUSTON—UNIV. PARK

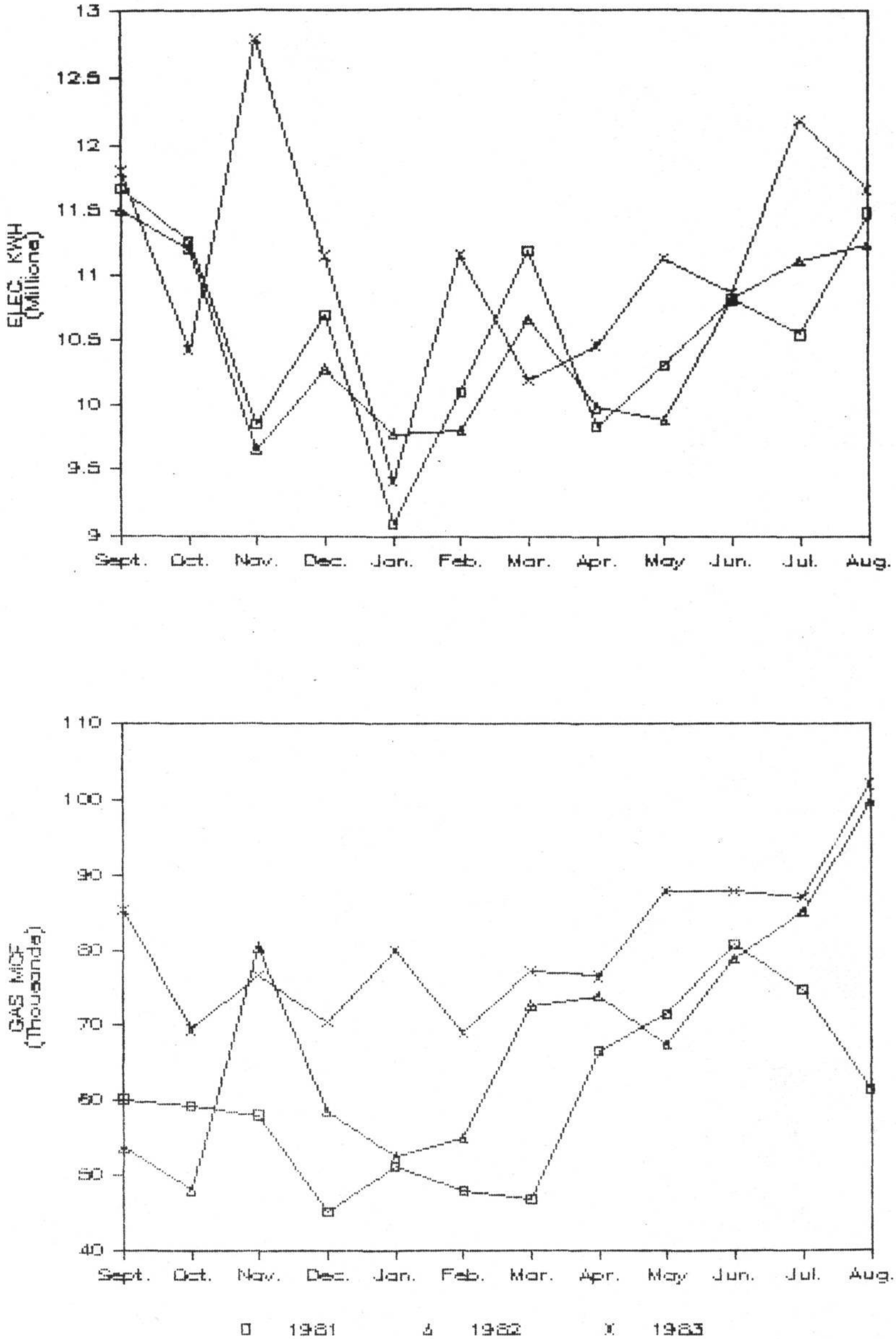


Figure C-30

TEXAS SOUTHERN UNIVERSITY

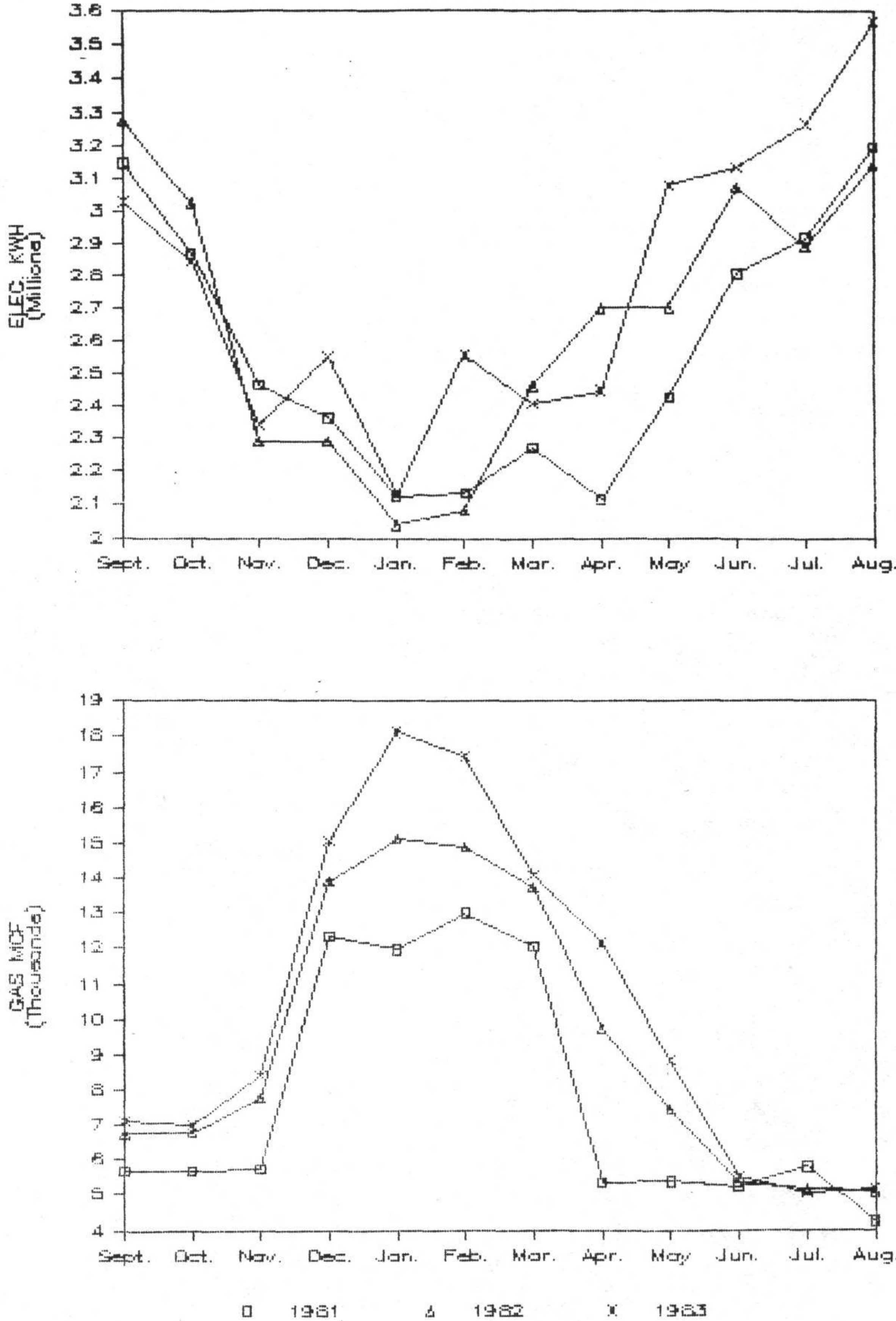
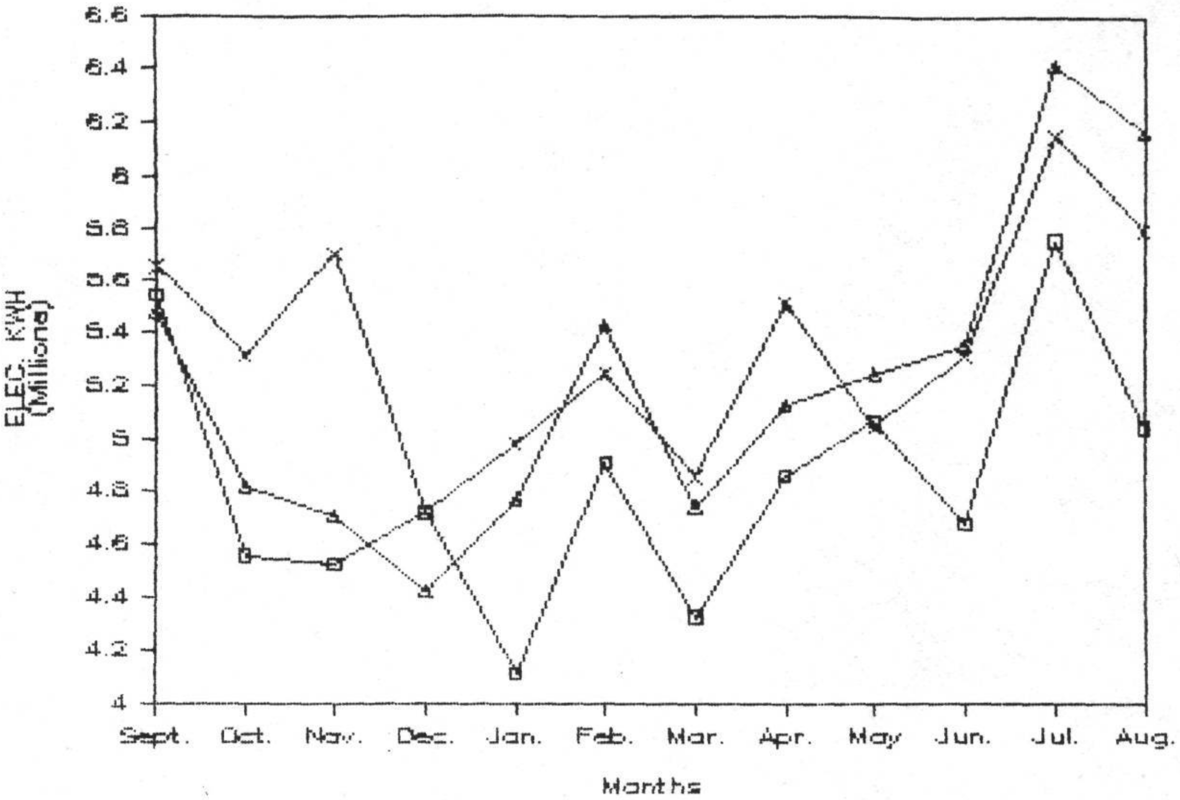


Figure C-31


6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
ELEC. KWH (Millions)
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Months

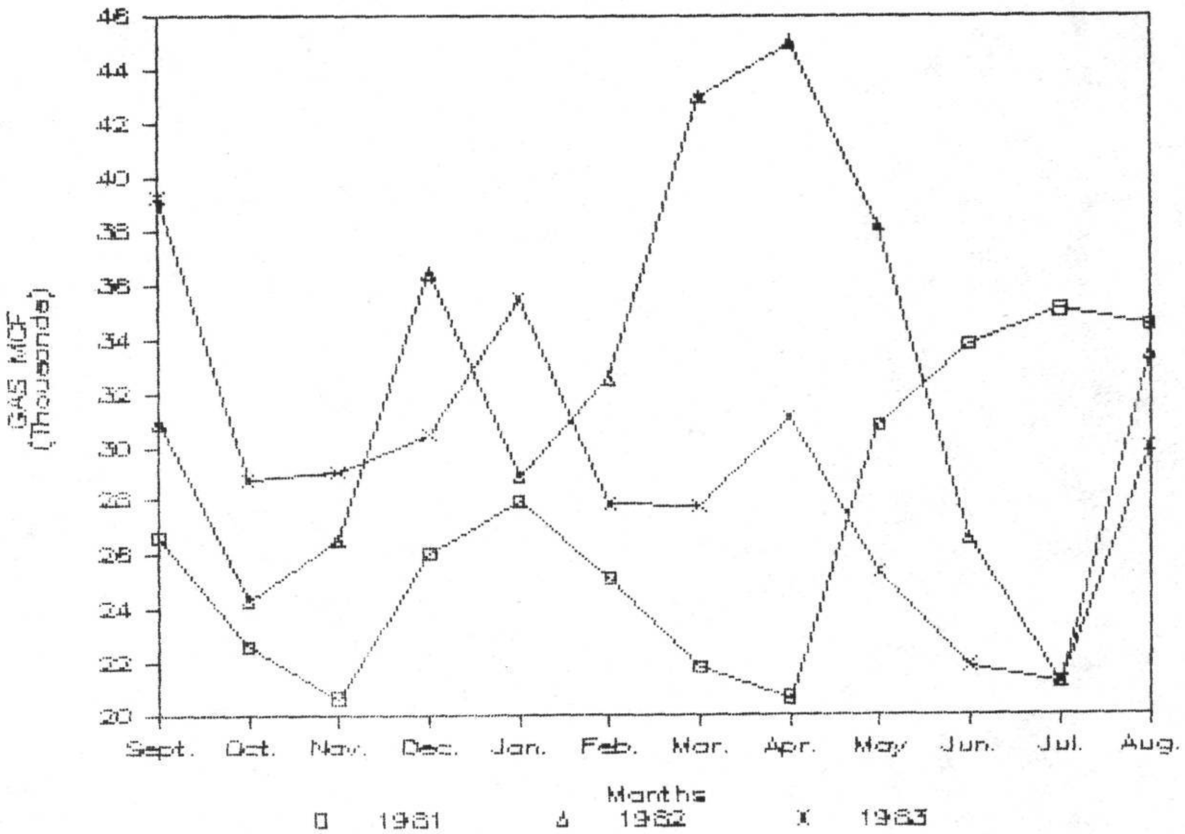

46
44
42
40
38
36
34
32
30
28
26
24
22
20
GAS MCF (Thousands)
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Months
1981
1982
1983

Figure C-32

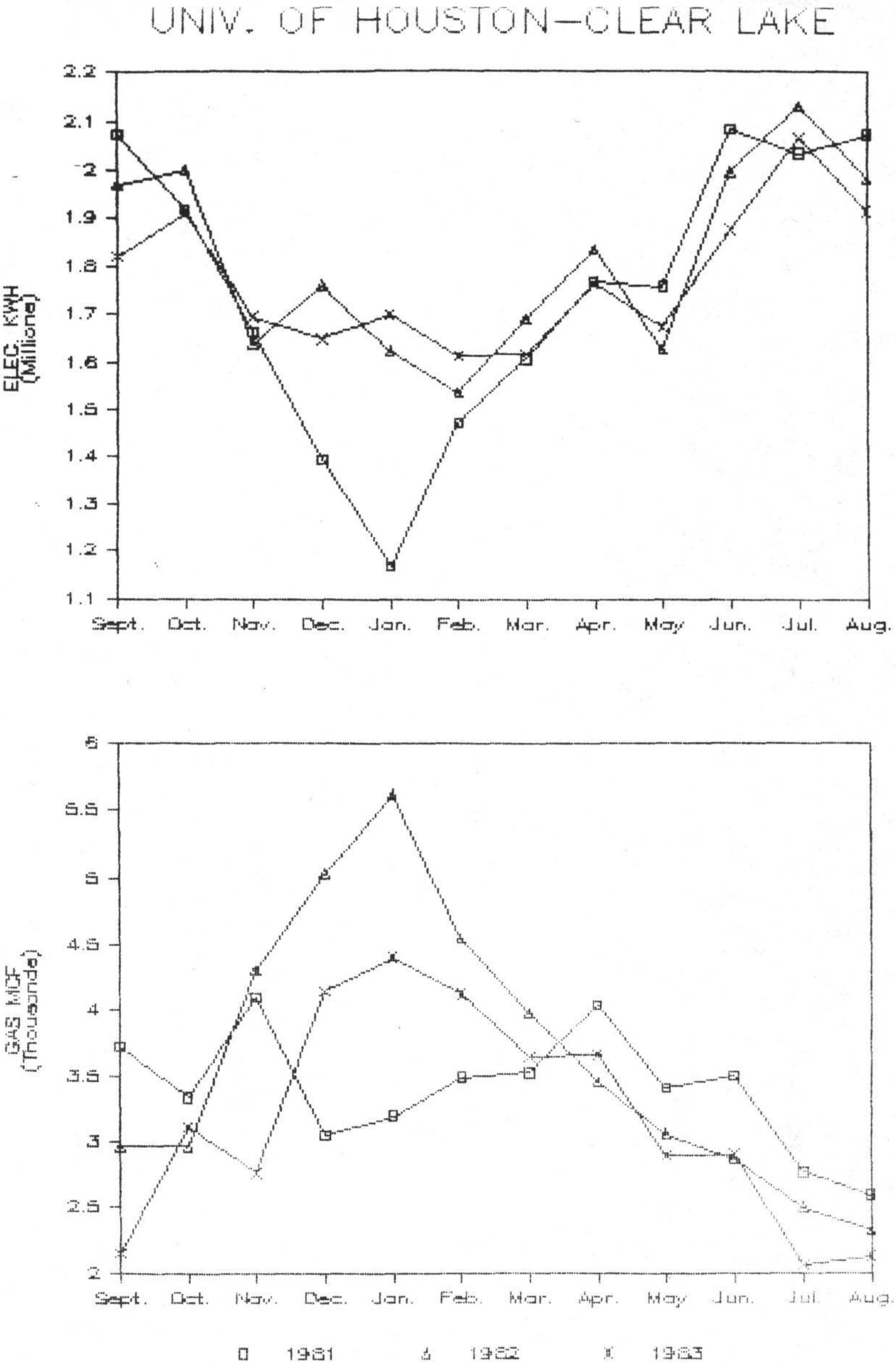

UNIV. OF HOUSTON—CLEAR LAKE
ELEC. KWH (Millions)
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
6
5.5
5
4.5
4
3.5
3
2.5
2
1981
1982
1983

Figure C-33

STEPHEN F.AUSTIN UNIV.

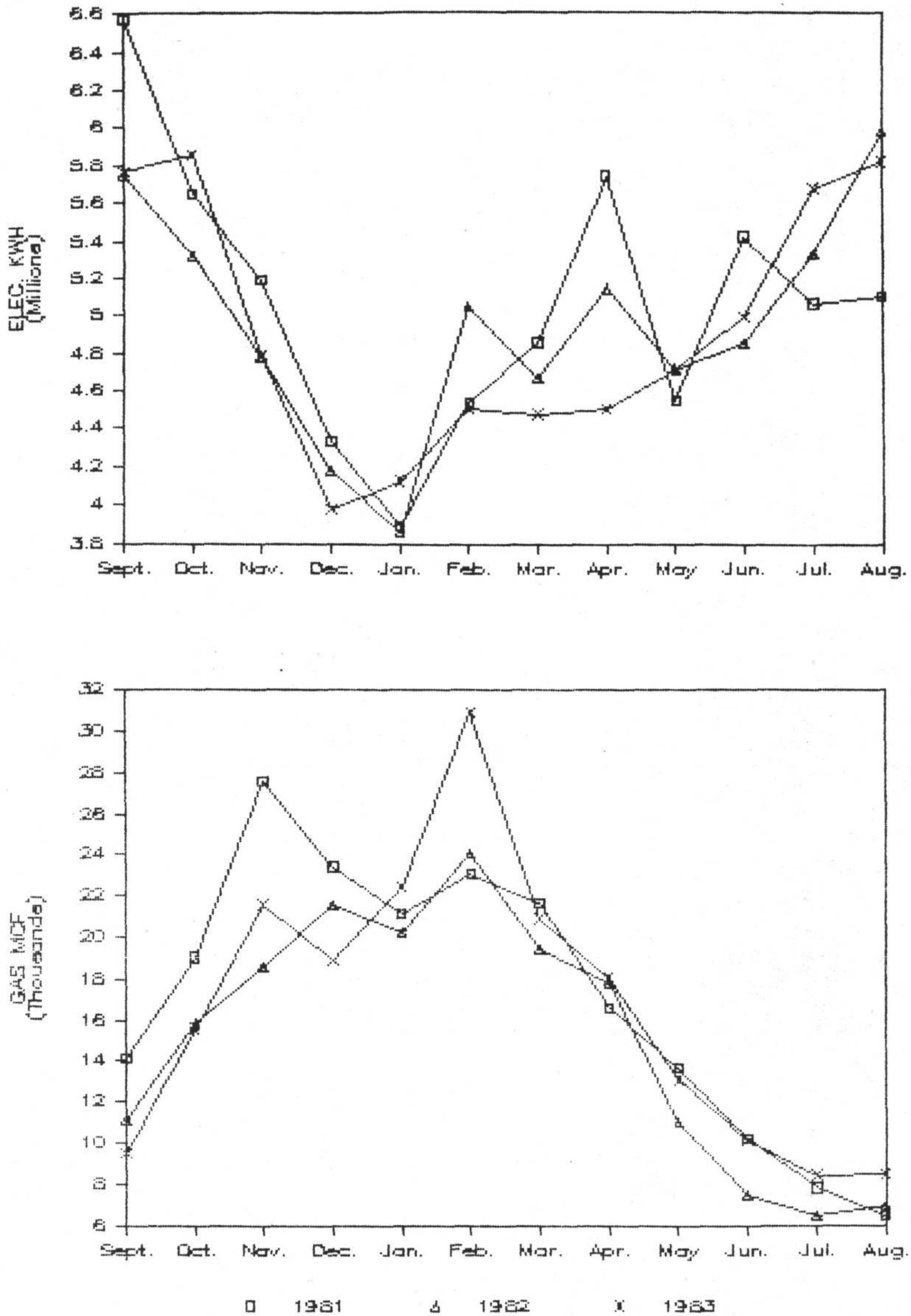


Figure C-34

TWU DALLAS CAMPUS

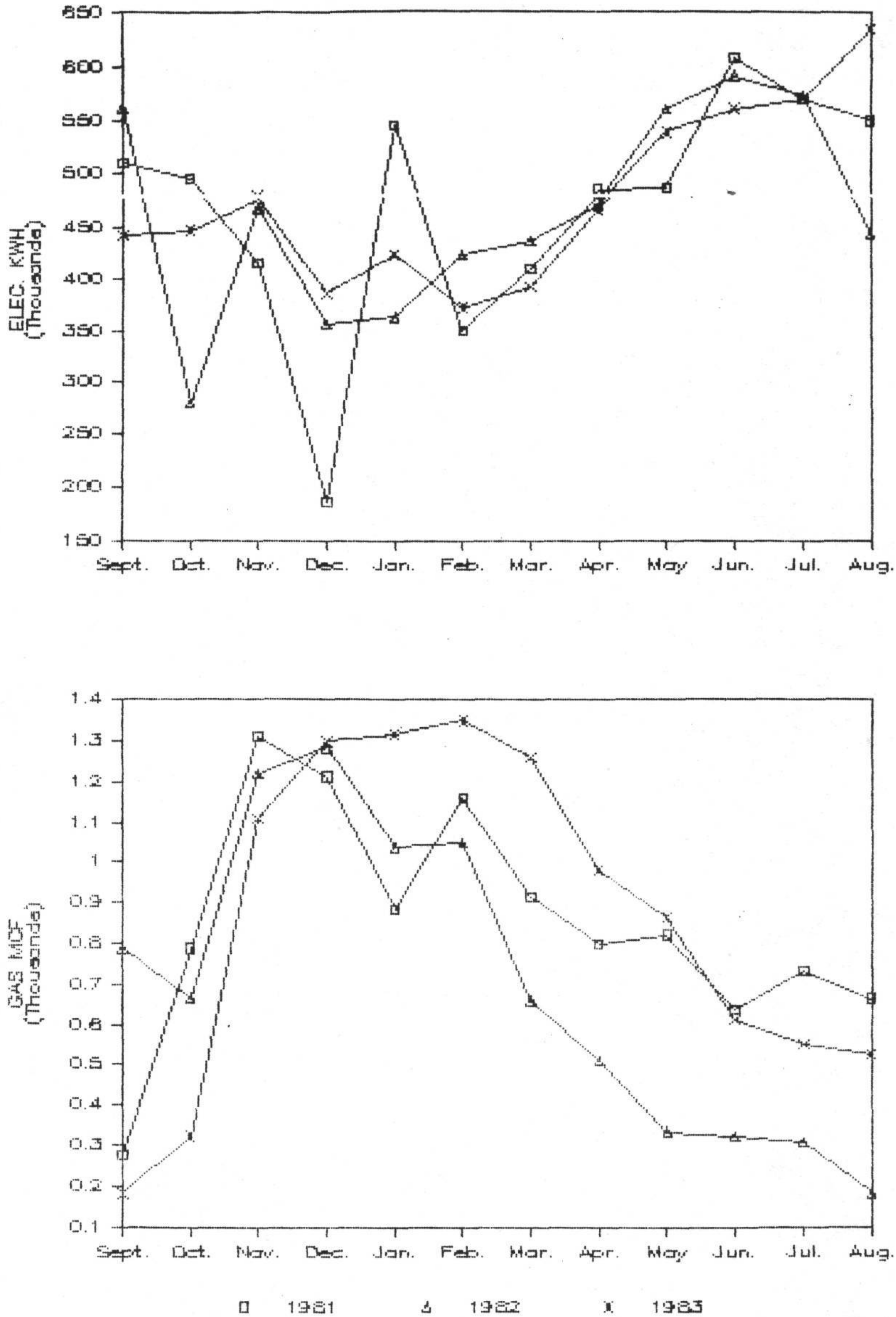
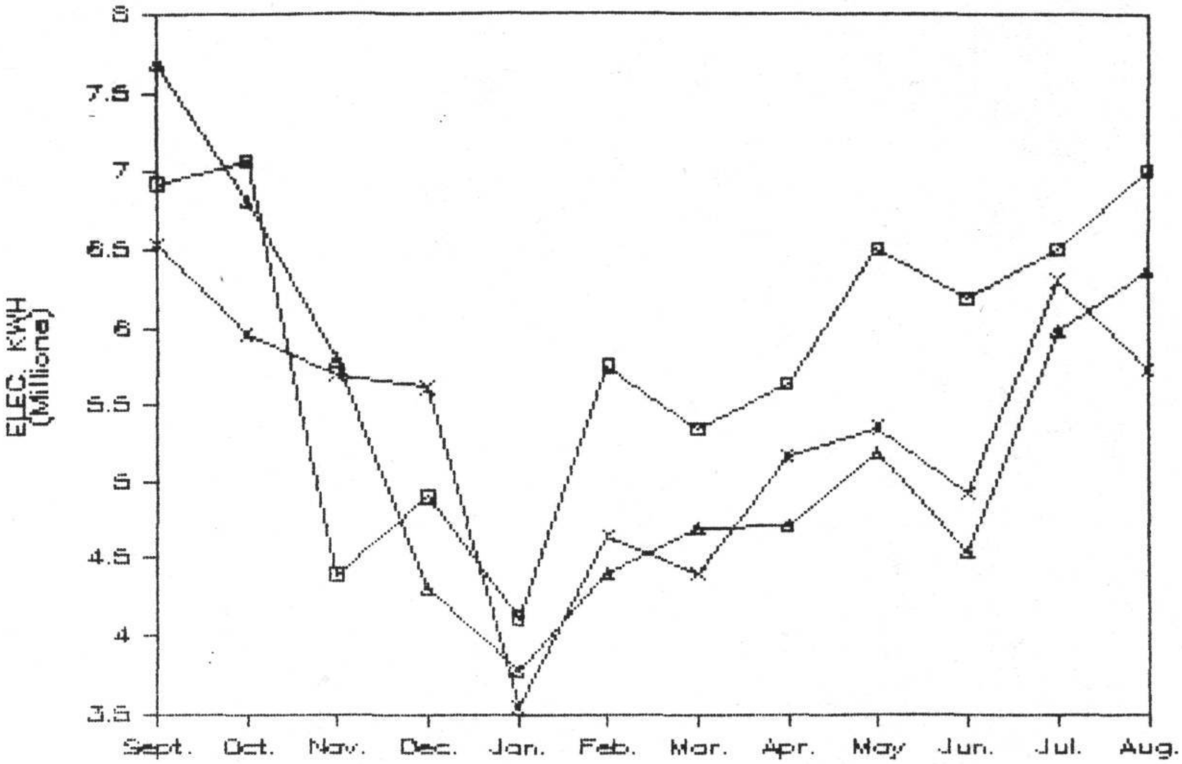


Figure C-35

NORTH TEXAS UNIVERSITY



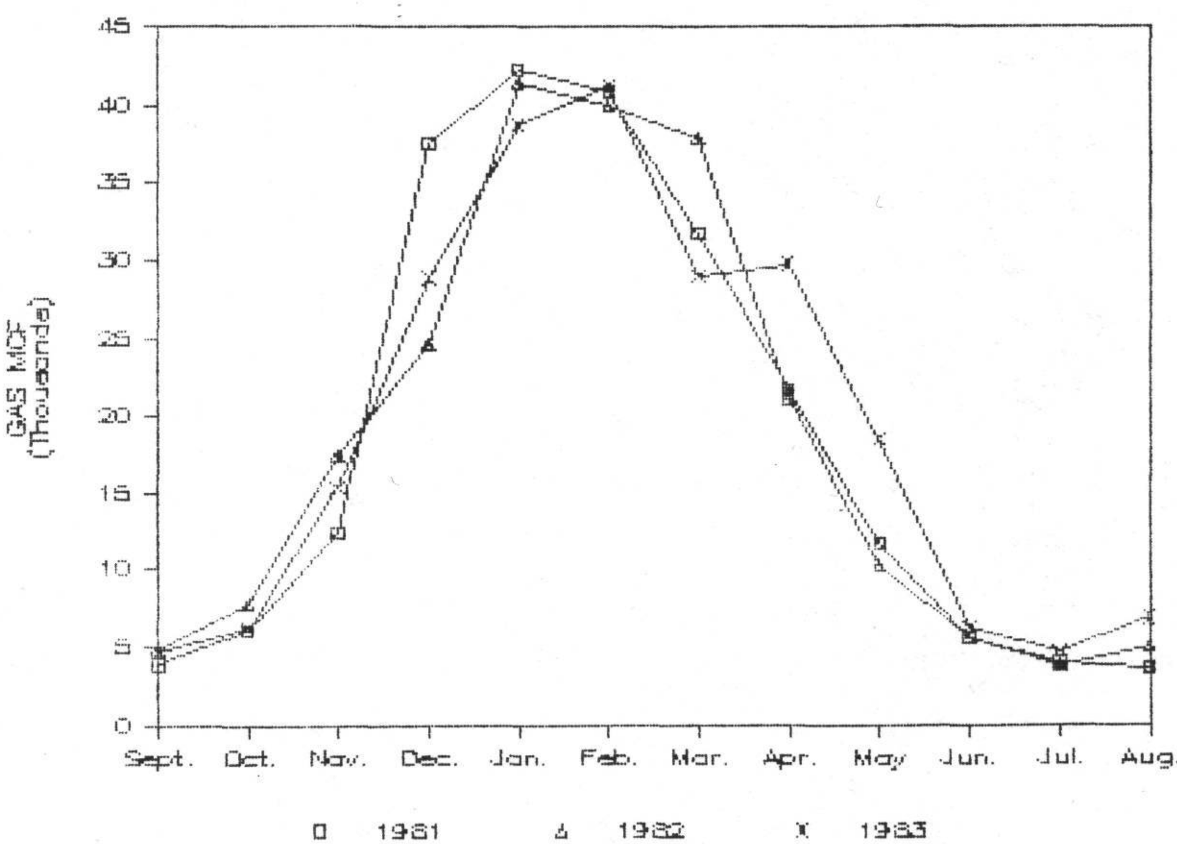


Figure C-36

LAMAR UNIVERSITY

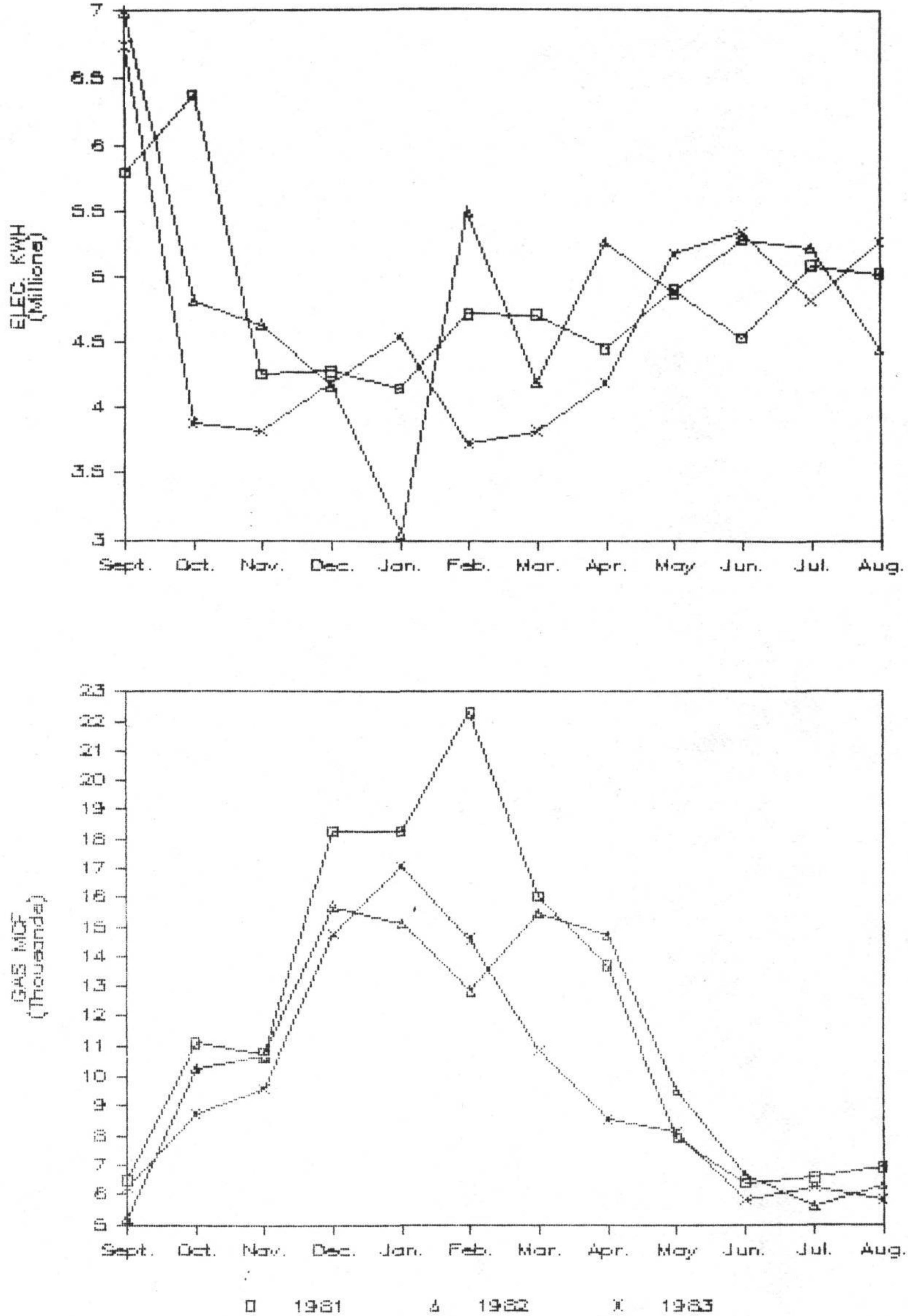


Figure C-37

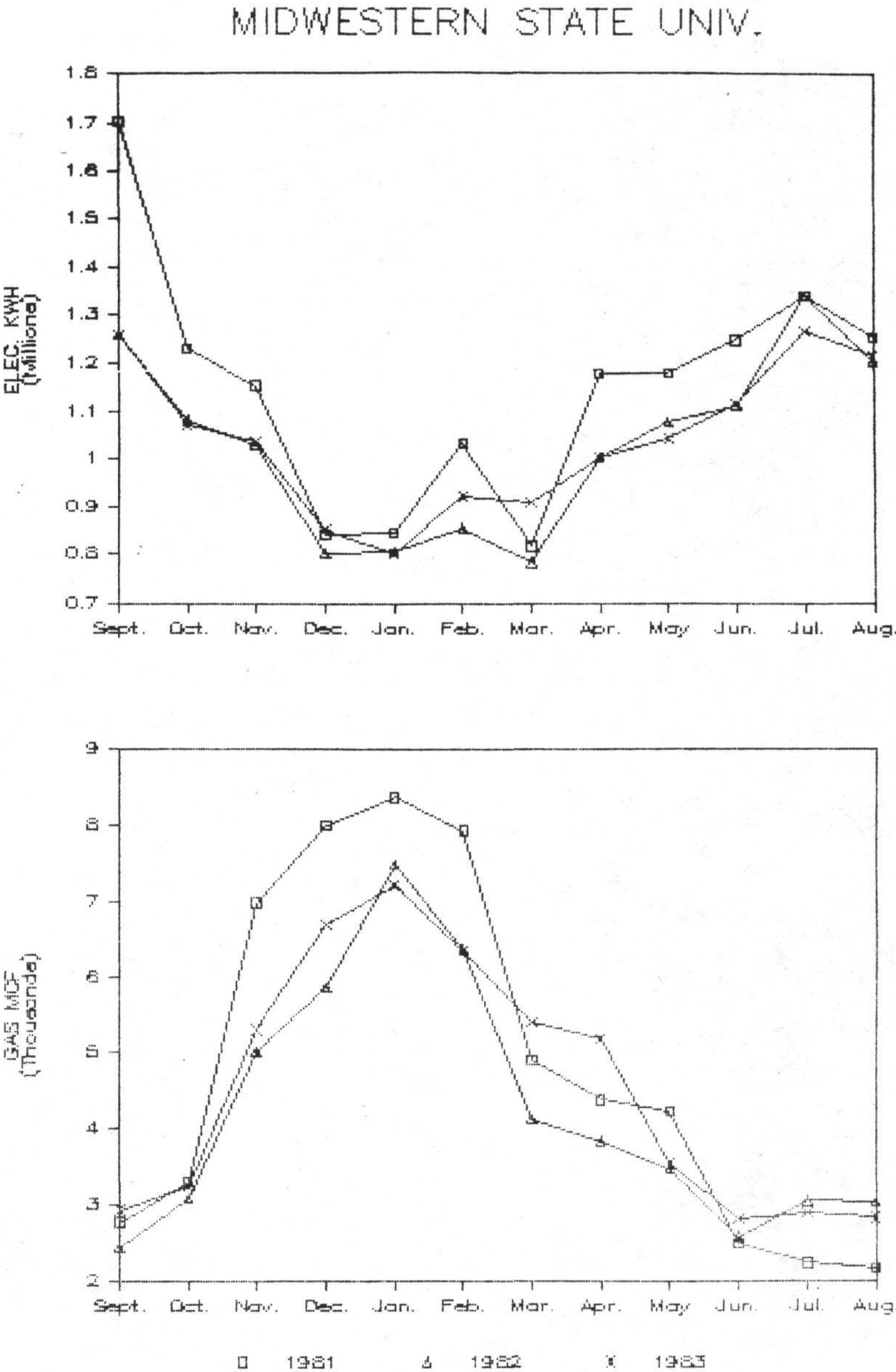
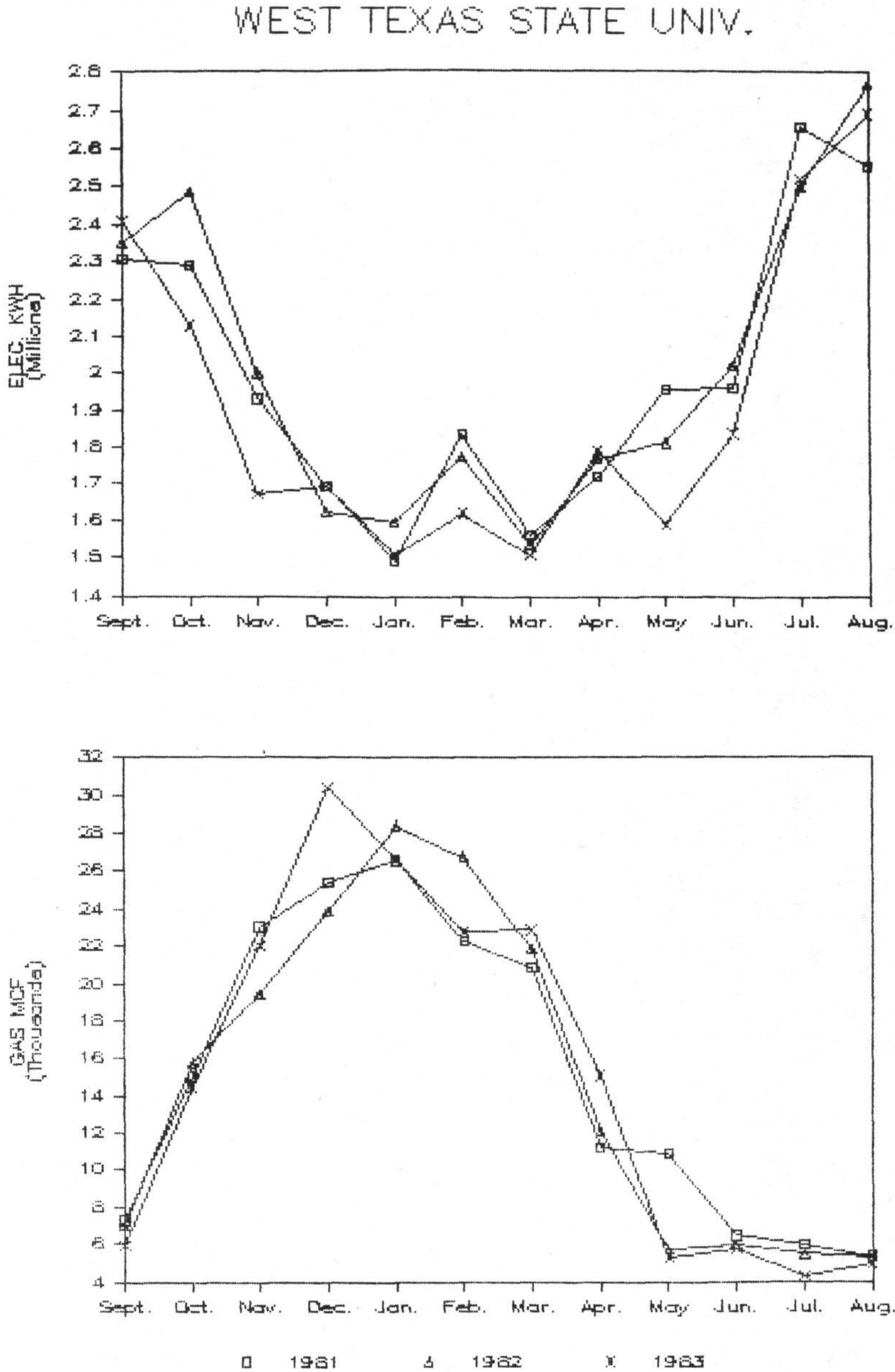

MIDWESTERN STATE UNIV.
ELEC. KWH (Millions)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
9
8
7
6
5
4
3
2
1981
1982
1983

Figure C-38



WEST TEXAS STATE UNIV.
ELEC. KWH (Millions)
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
1981
1982
1983

Figure C-39

SAM HOUSTON STATE UNIVERSITY

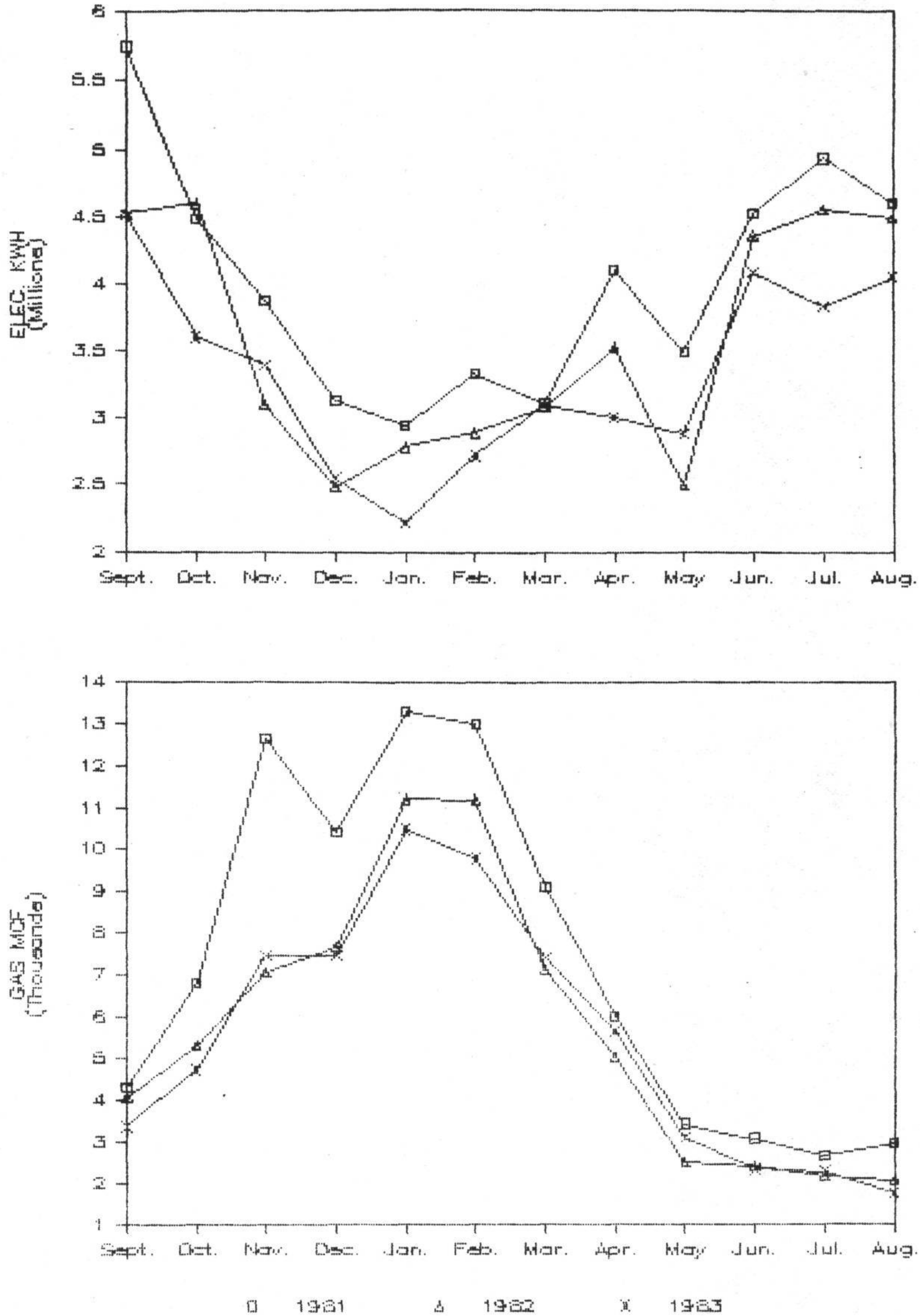


Figure C-40

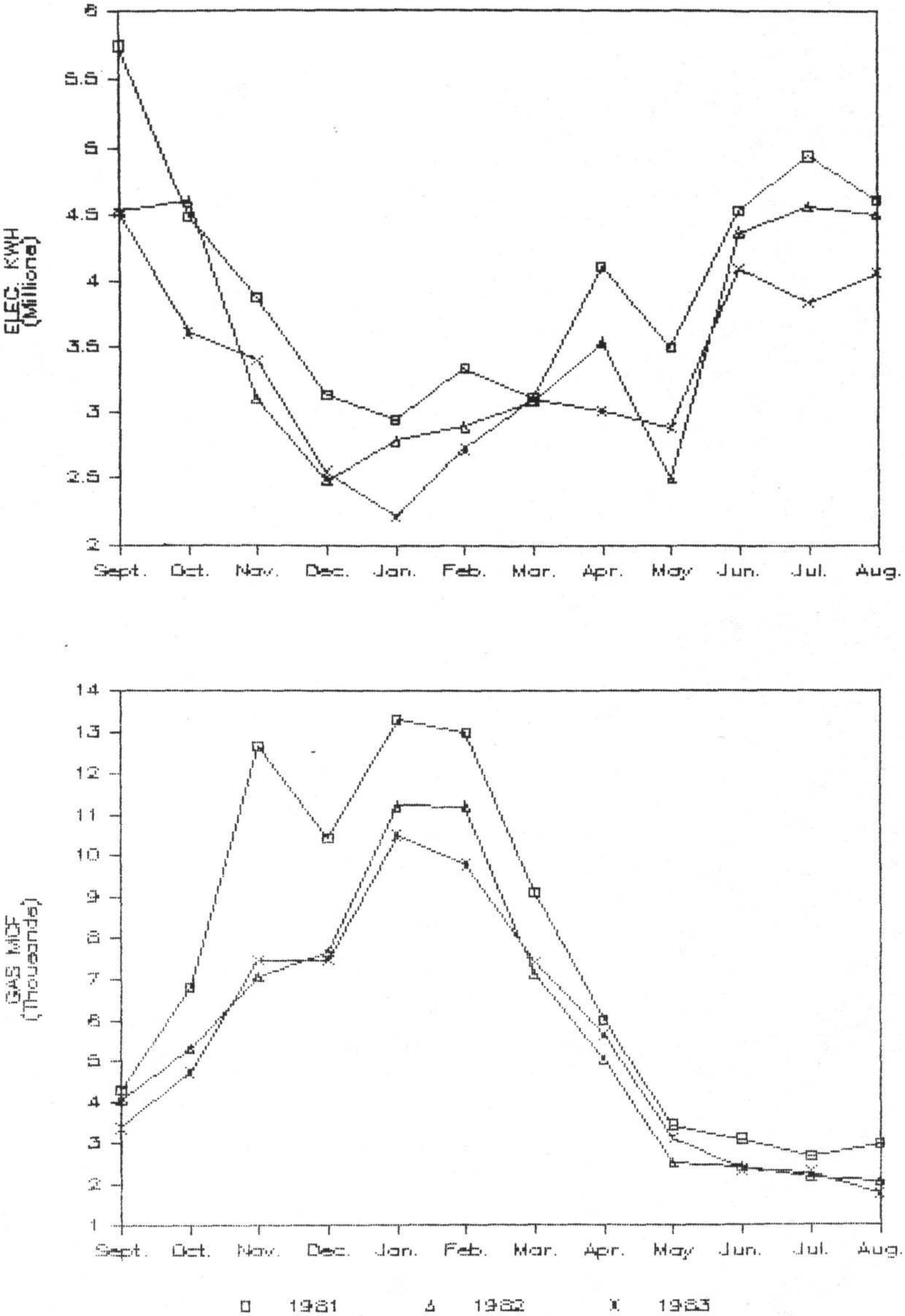

ELEC. KWH (Millions)
6
5.5
5
4.5
4
3.5
3
2.5
2
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
GAS MCF (Thousands)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
□ 1981
Δ 1982
X 1983

Figure C-41

ANGELO STATE UNIVERSITY

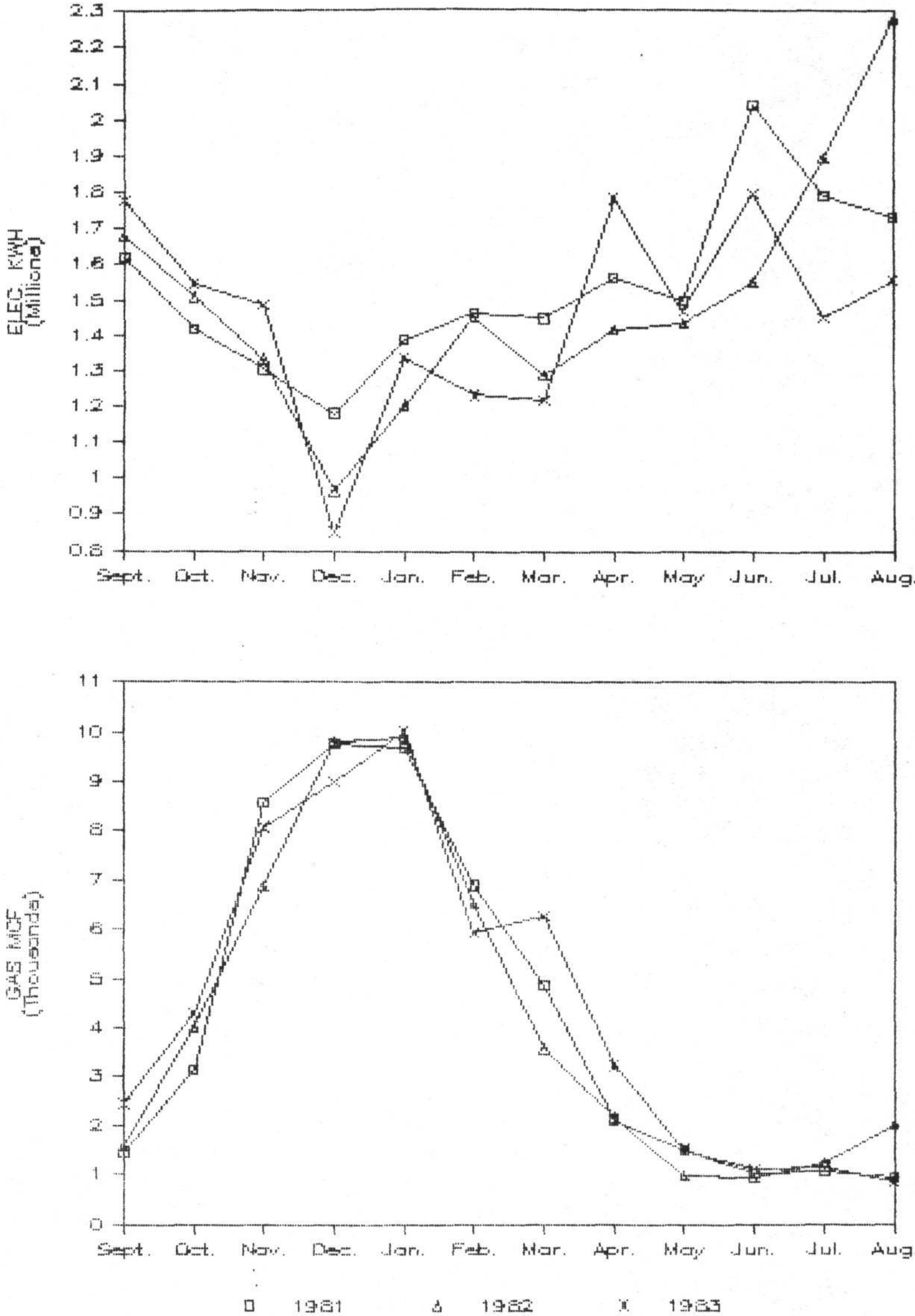


Figure C-42

TARLETON STATE UNIVERSITY

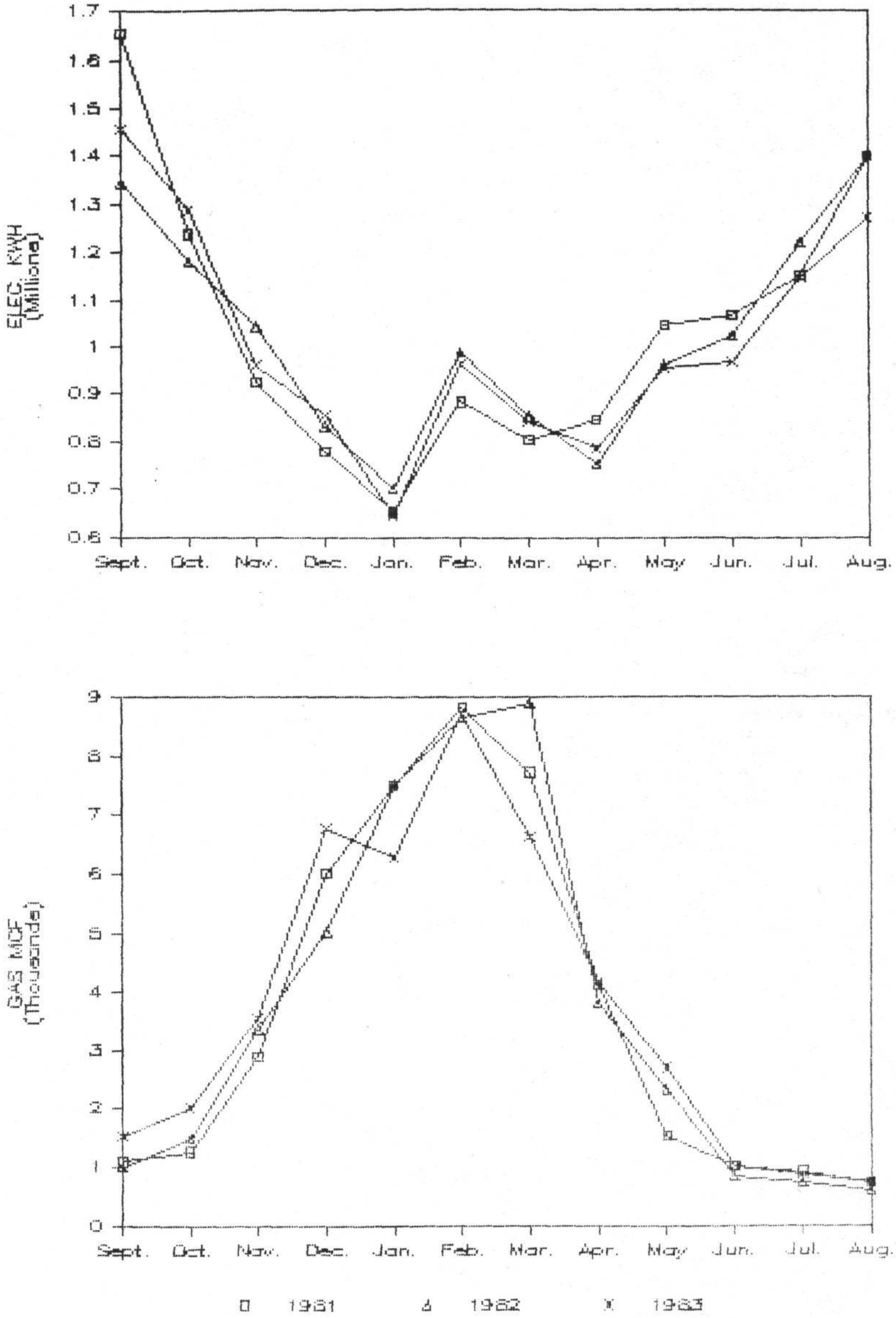
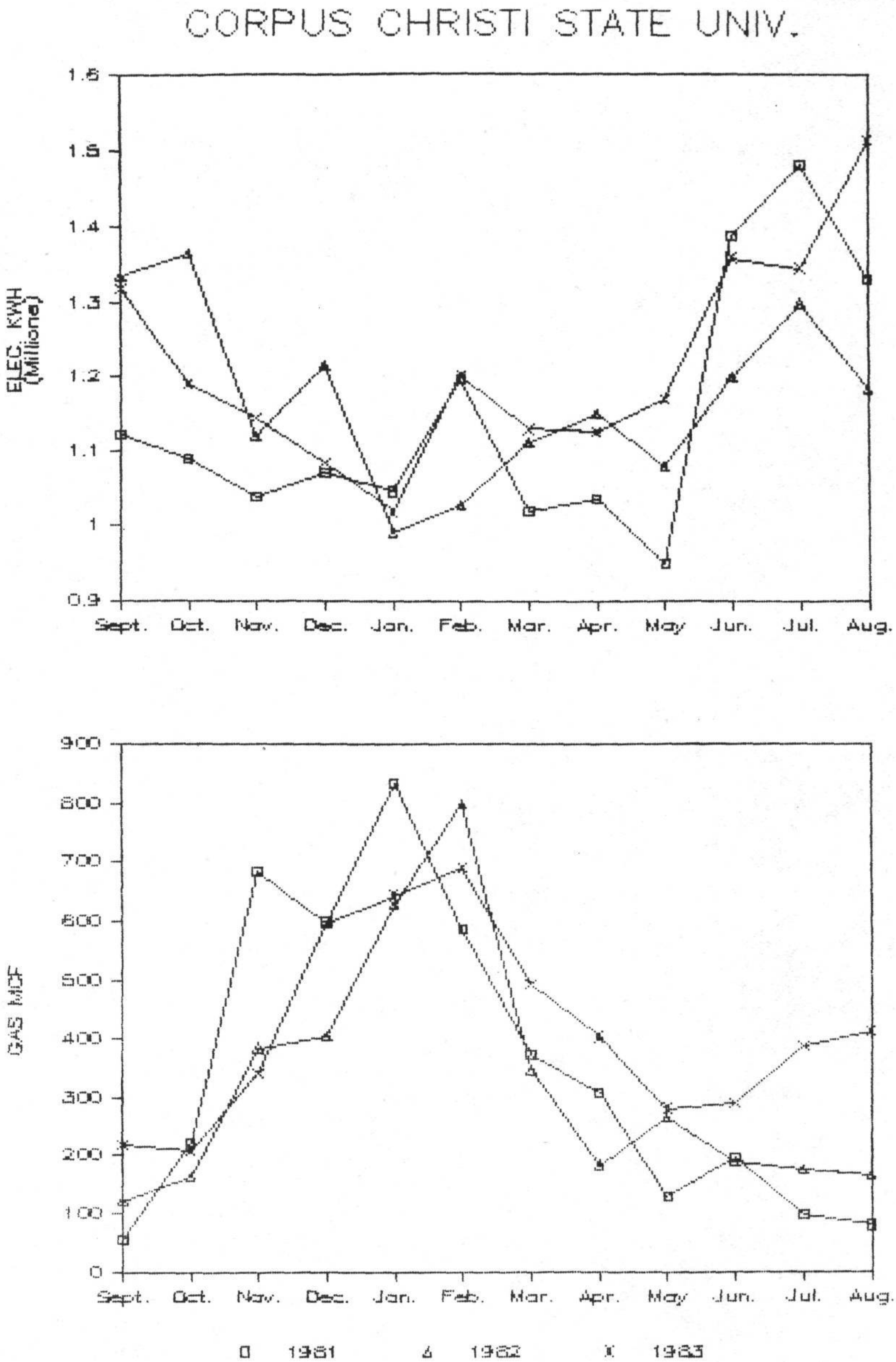


Figure C-43



CORPUS CHRISTI STATE UNIV.
ELEC. KWH (Millions)
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
GAS MCF
900
800
700
600
500
400
300
200
100
0
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
□ 1981 △ 1982 X 1983

Figure C-44

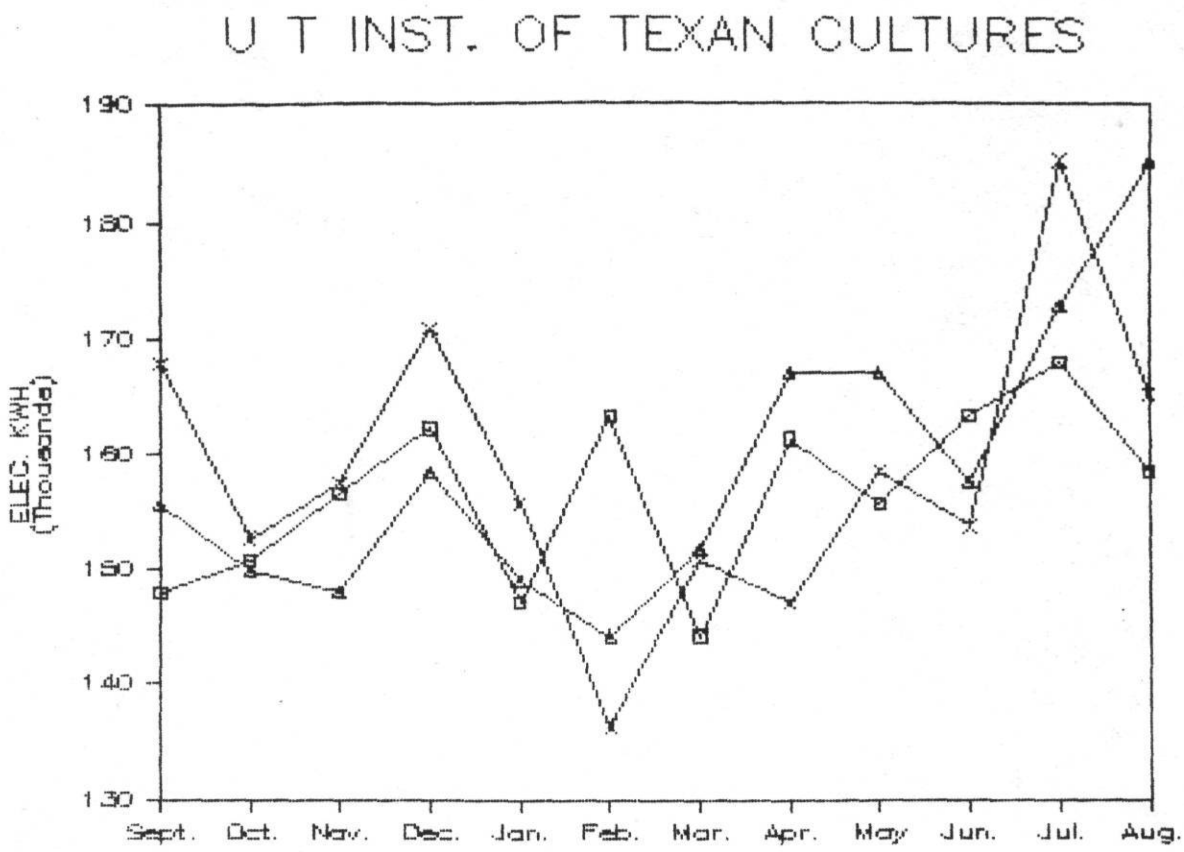
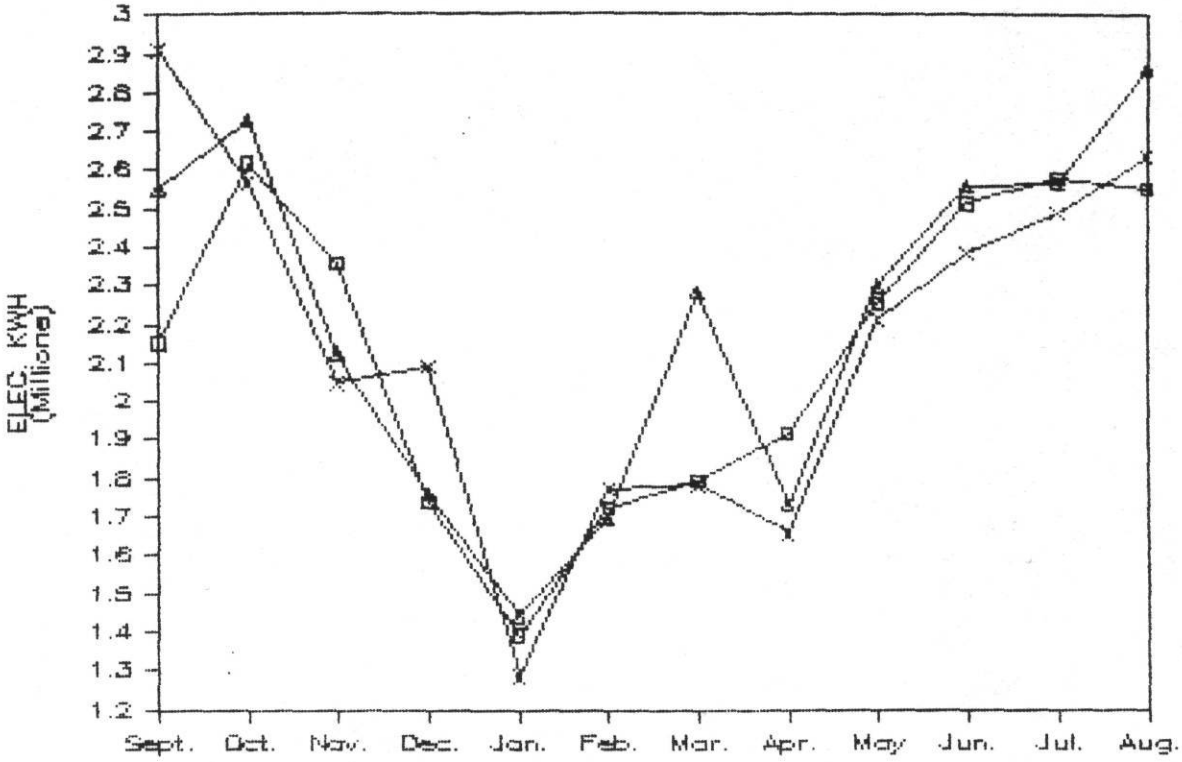

U T INST. OF TEXAN CULTURES
190
180
170
160
150
140
130
ELEC. KWH (Thousands)
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.

Figure C-45

TEXAS A&I UNIVERSITY



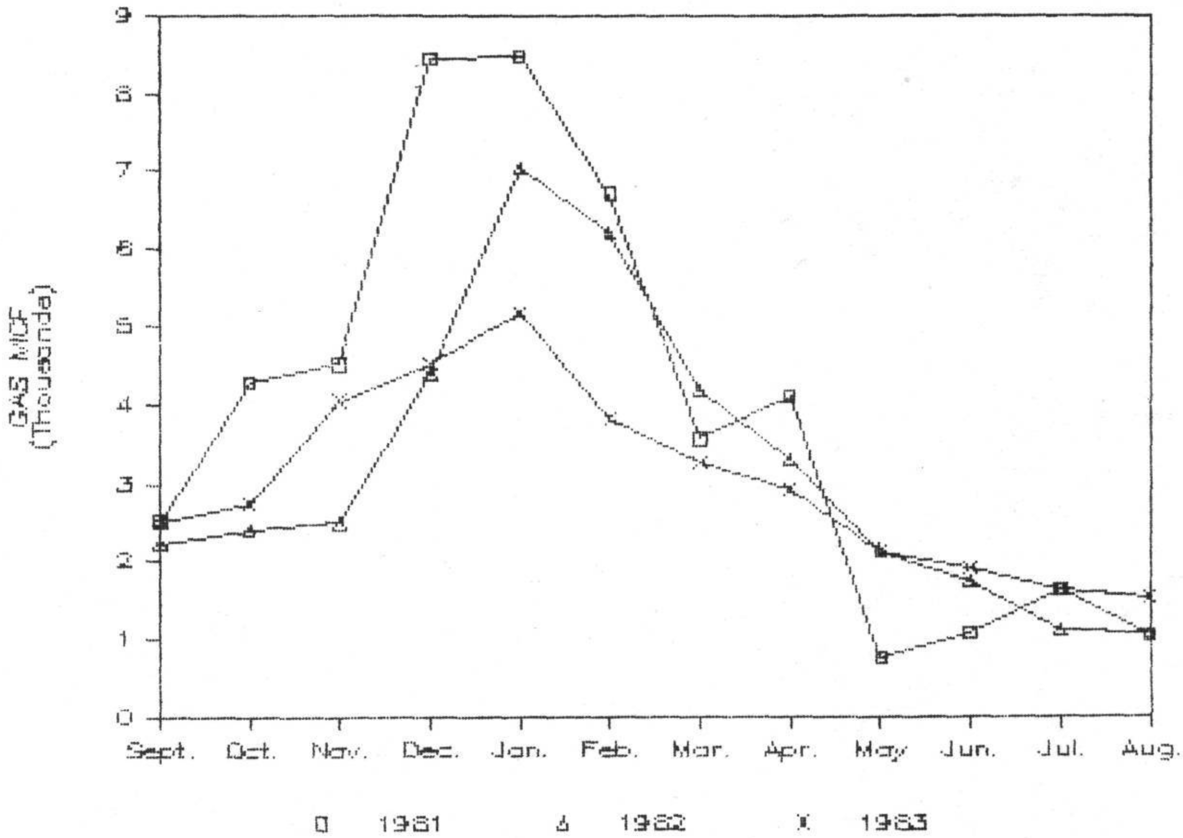
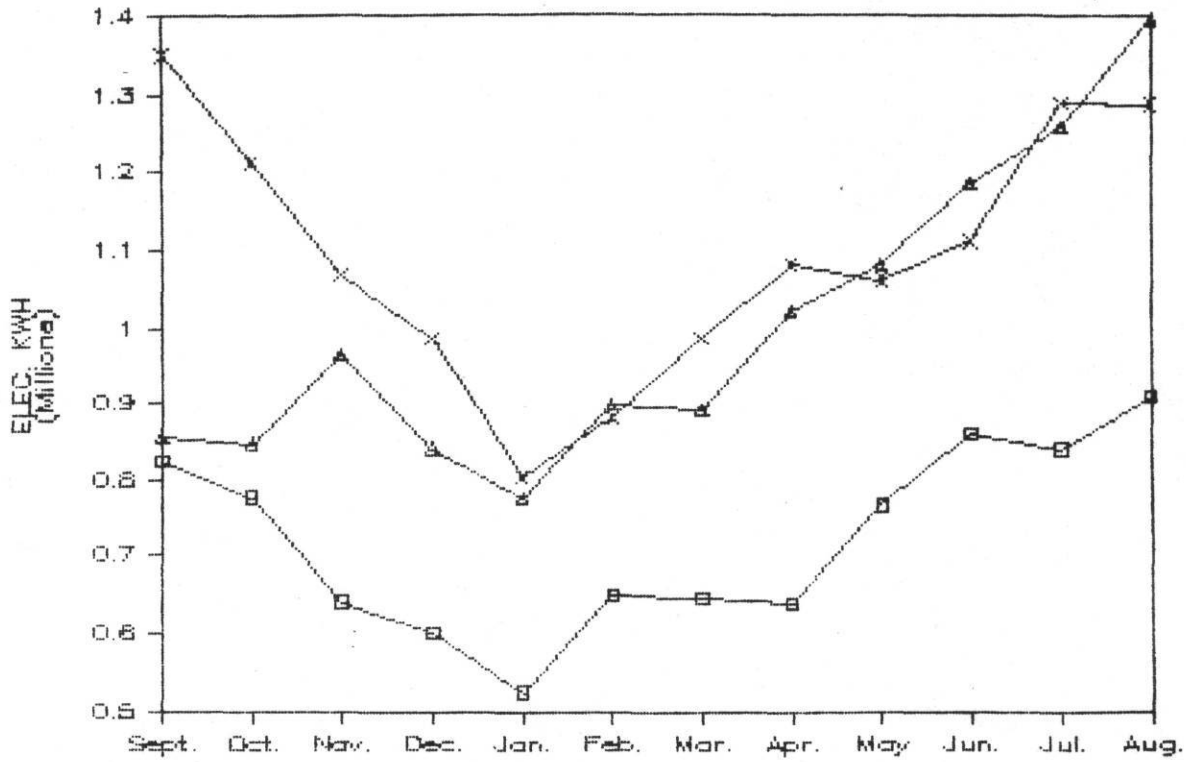


Figure C-46

UNIV. OF HOUSTON—DOWN TOWN



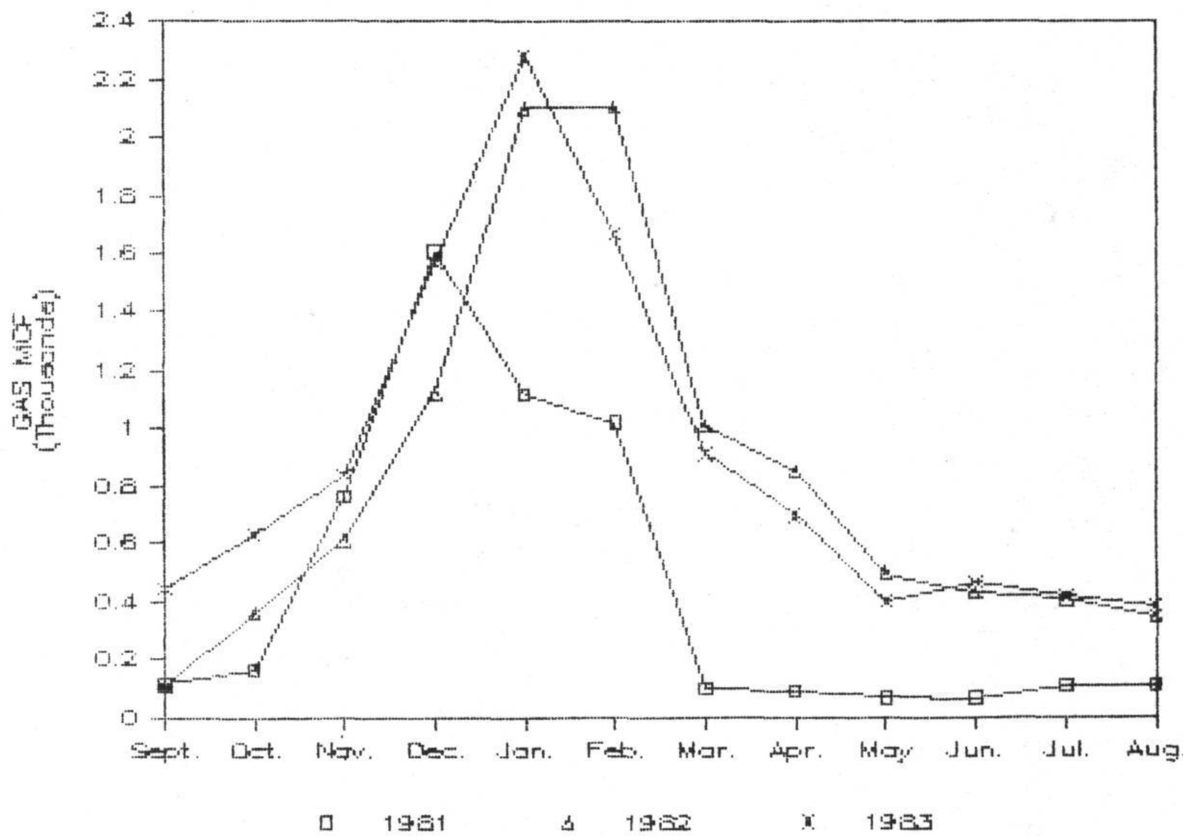
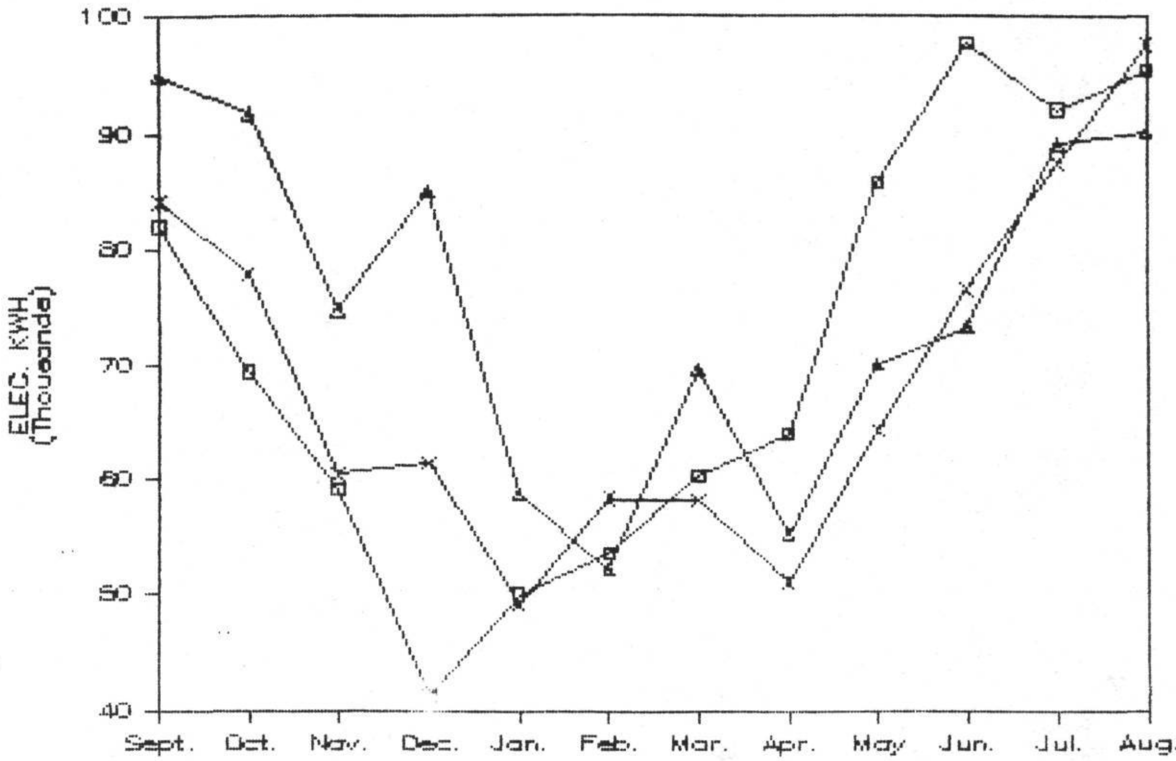
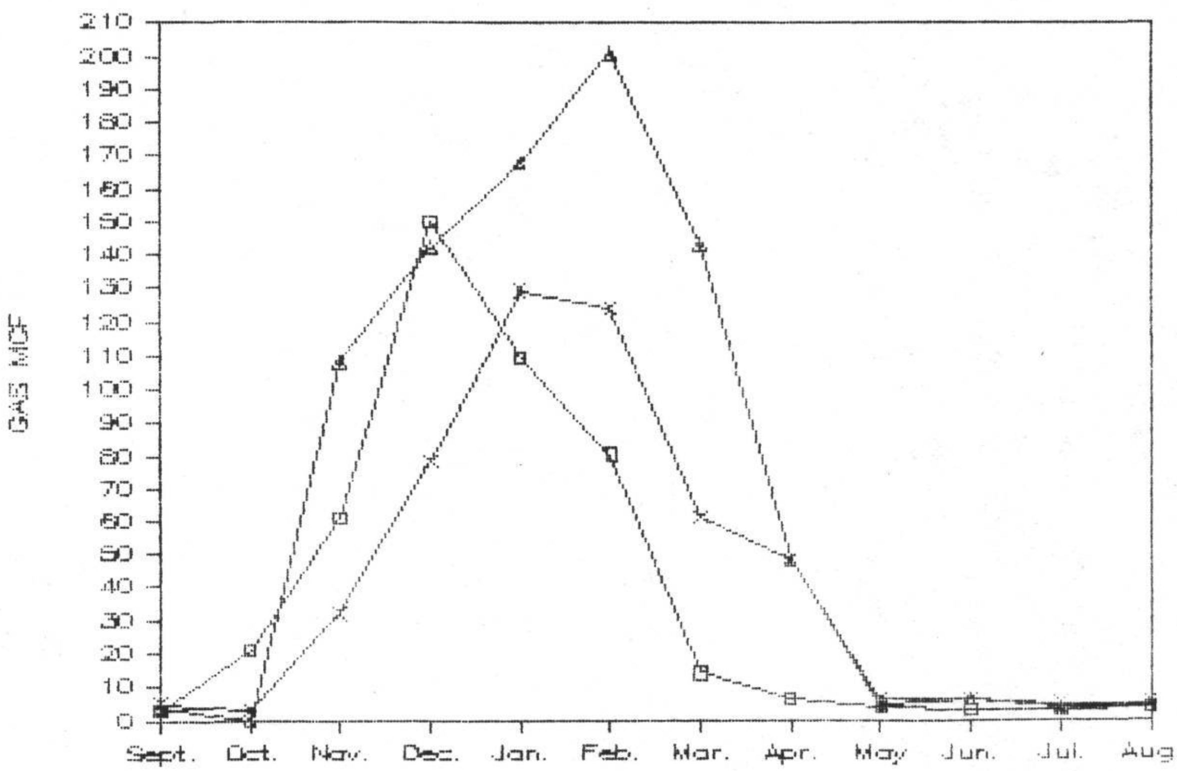


Figure C-47

EAST TEXAS UNIV. AT TEXARKANA





□ 1981 △ 1982 X 1983

Figure C-48

SUL ROSS STATE UNIV.

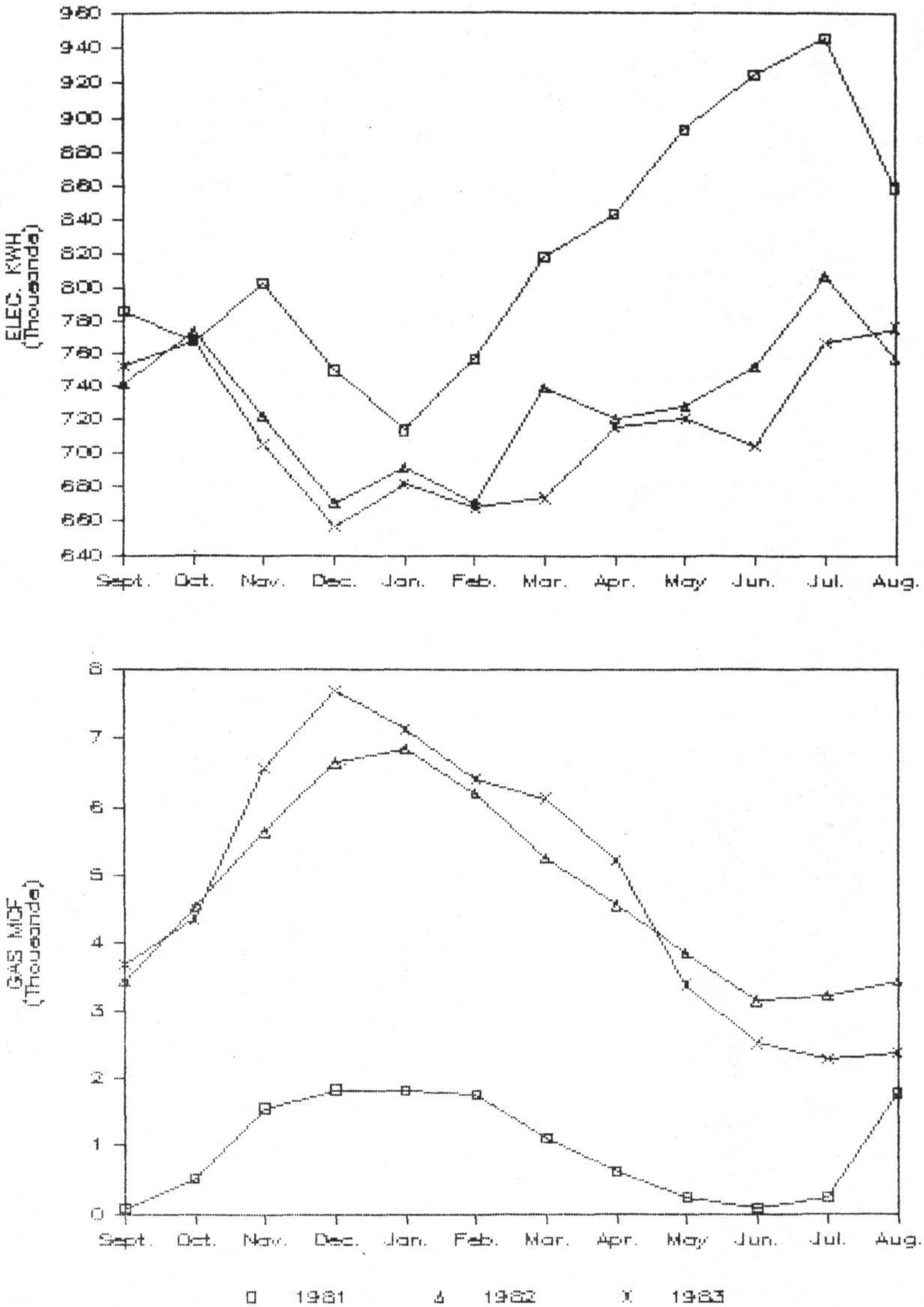


Figure C-49

COFFIELD,BETO UNITS

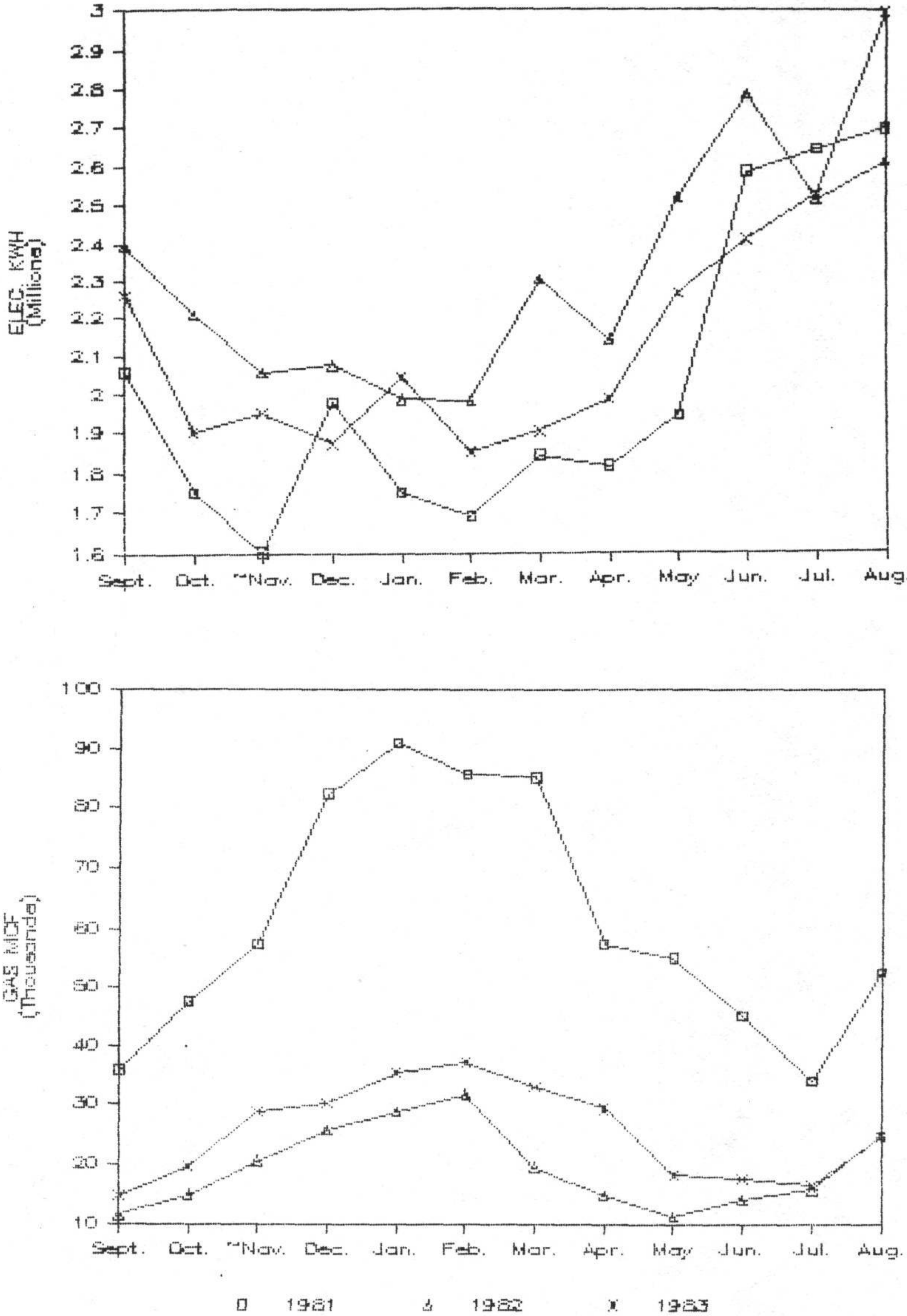
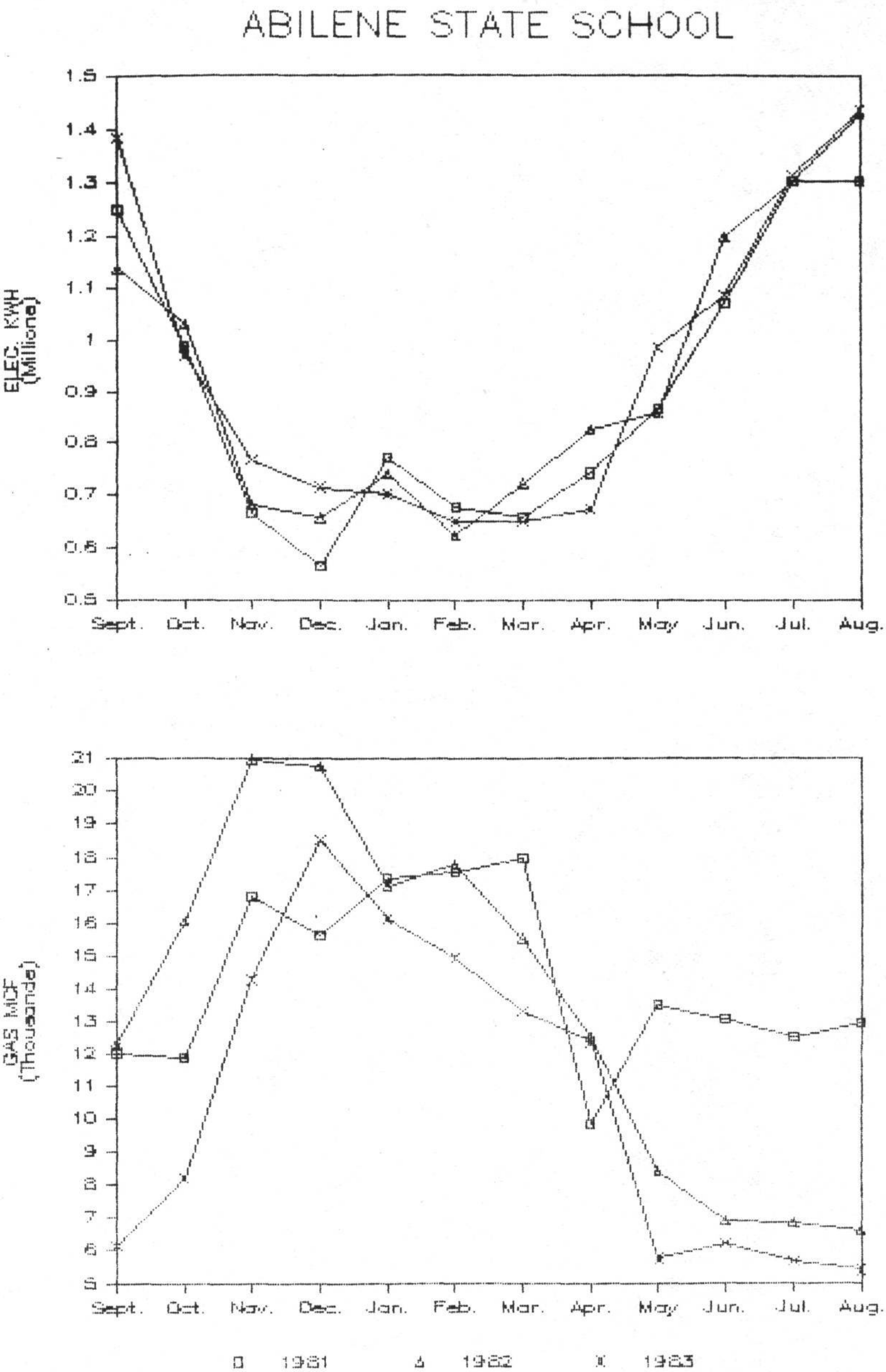


Figure C-50



ABILENE STATE SCHOOL
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
ELEC. KWH (Millions)
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
GAS MCF (Thousands)
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
1981
1982
1983

Figure C-51

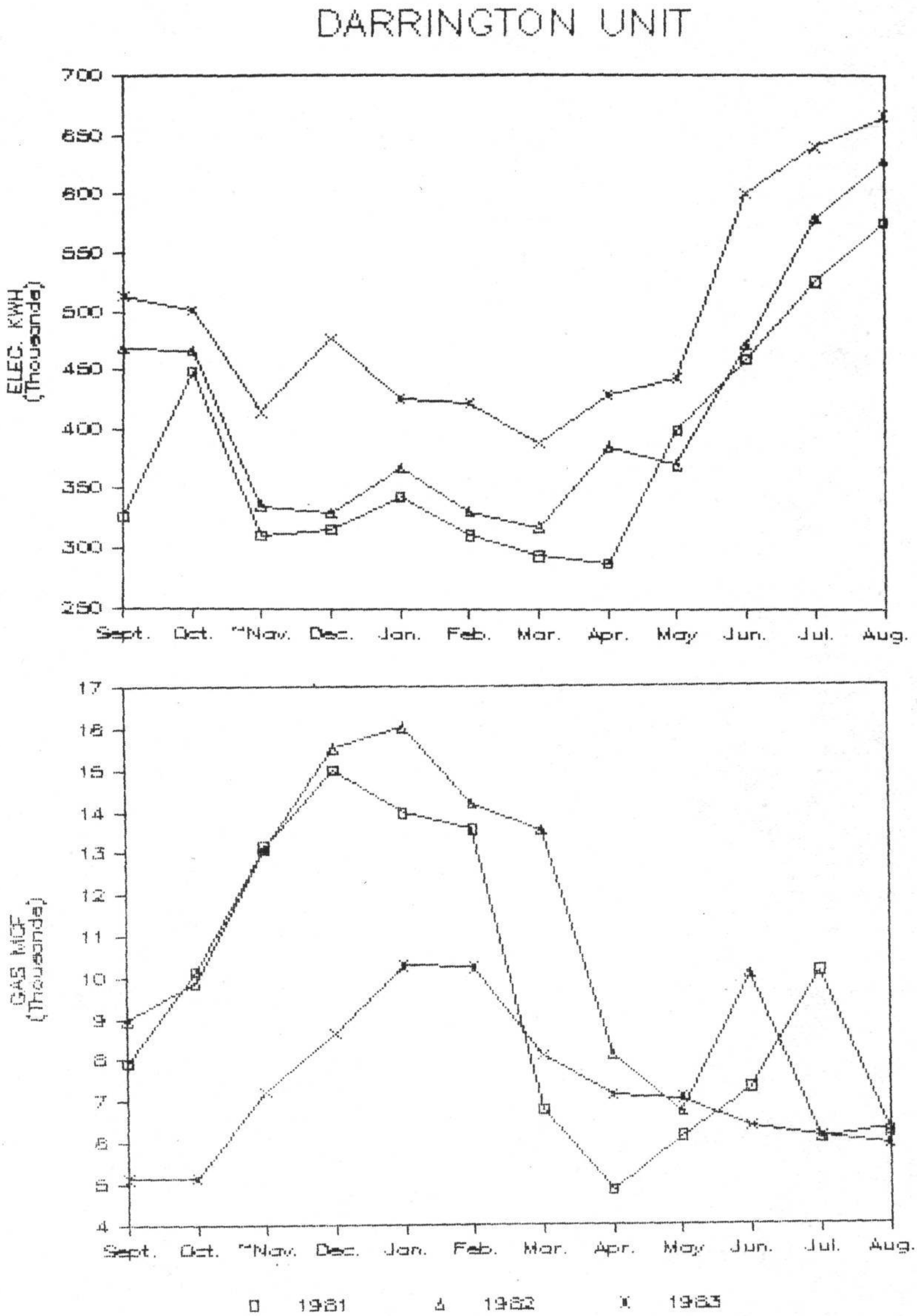
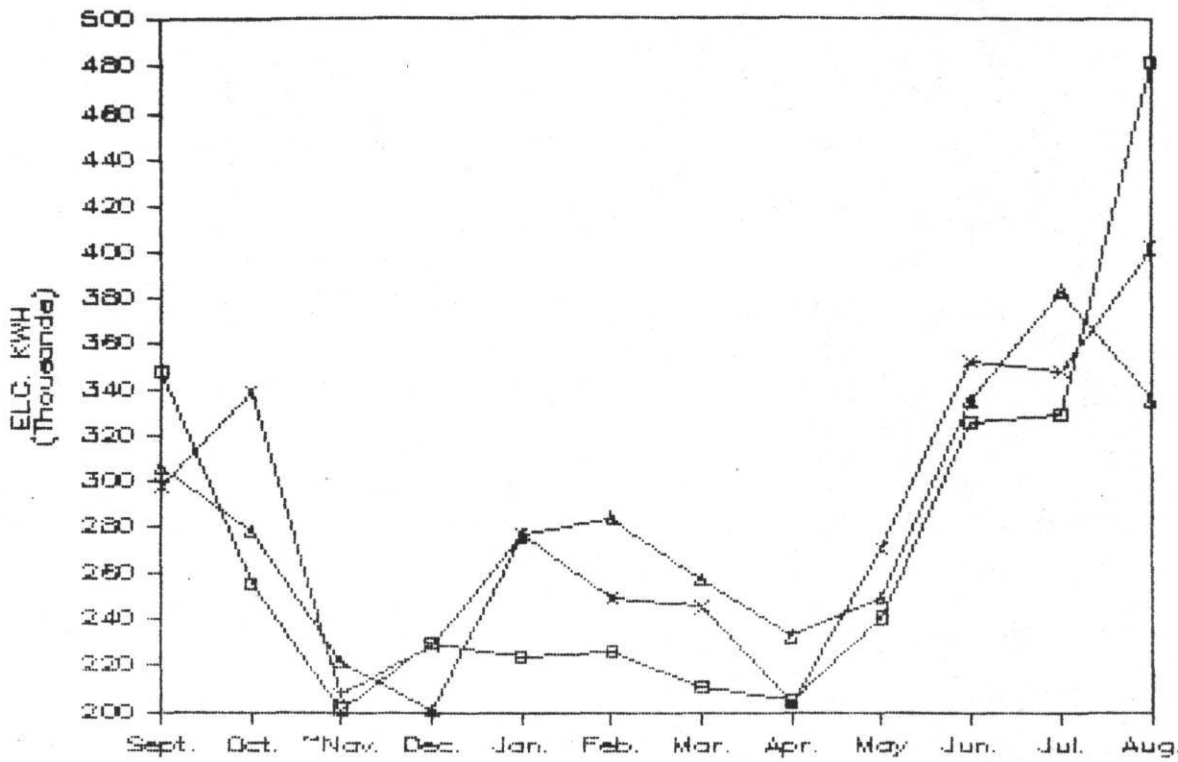

DARRINGTON UNIT
700
650
600
550
500
450
400
350
300
250
ELEC. KWH (Thousands)
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
17
16
15
14
13
12
11
10
9
8
7
6
5
4
GAS MCF (Thousands)
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
1981
1982
1983

Figure C-52

GOREE UNIT



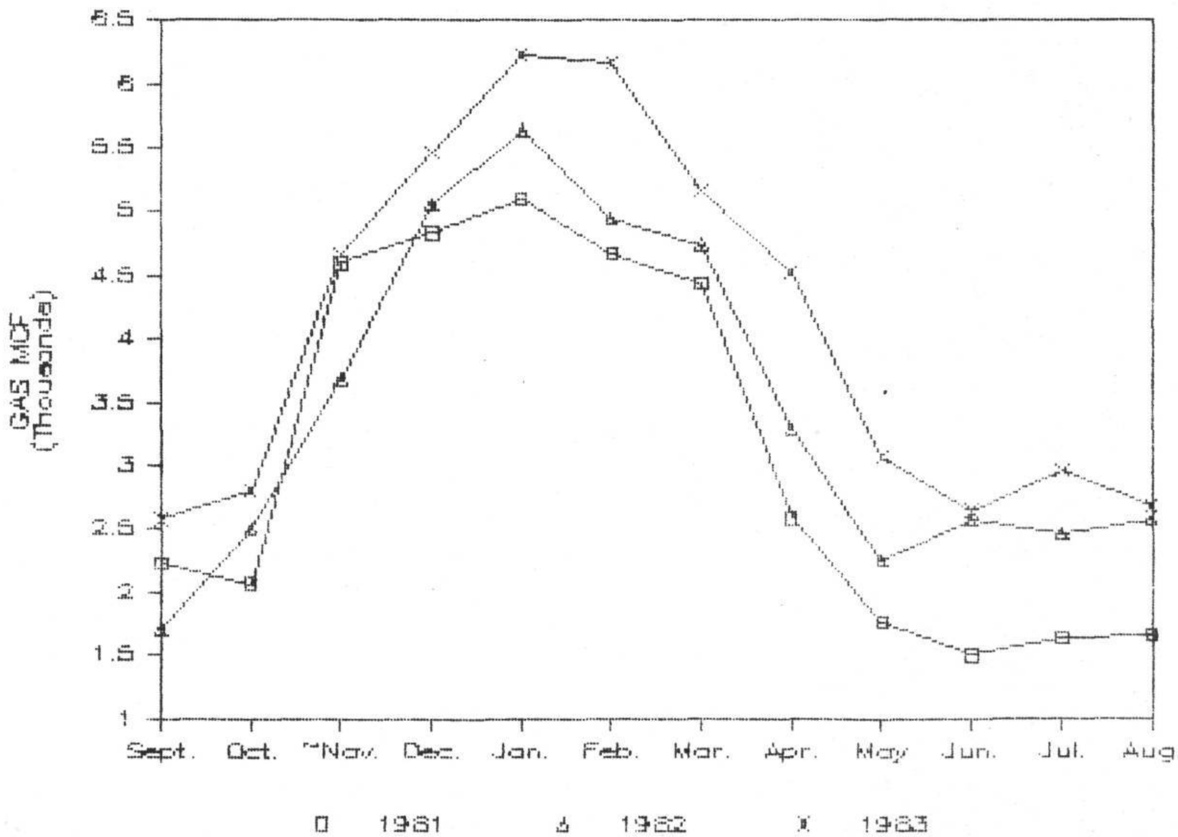


Figure C-53

CLEMENS UNIT

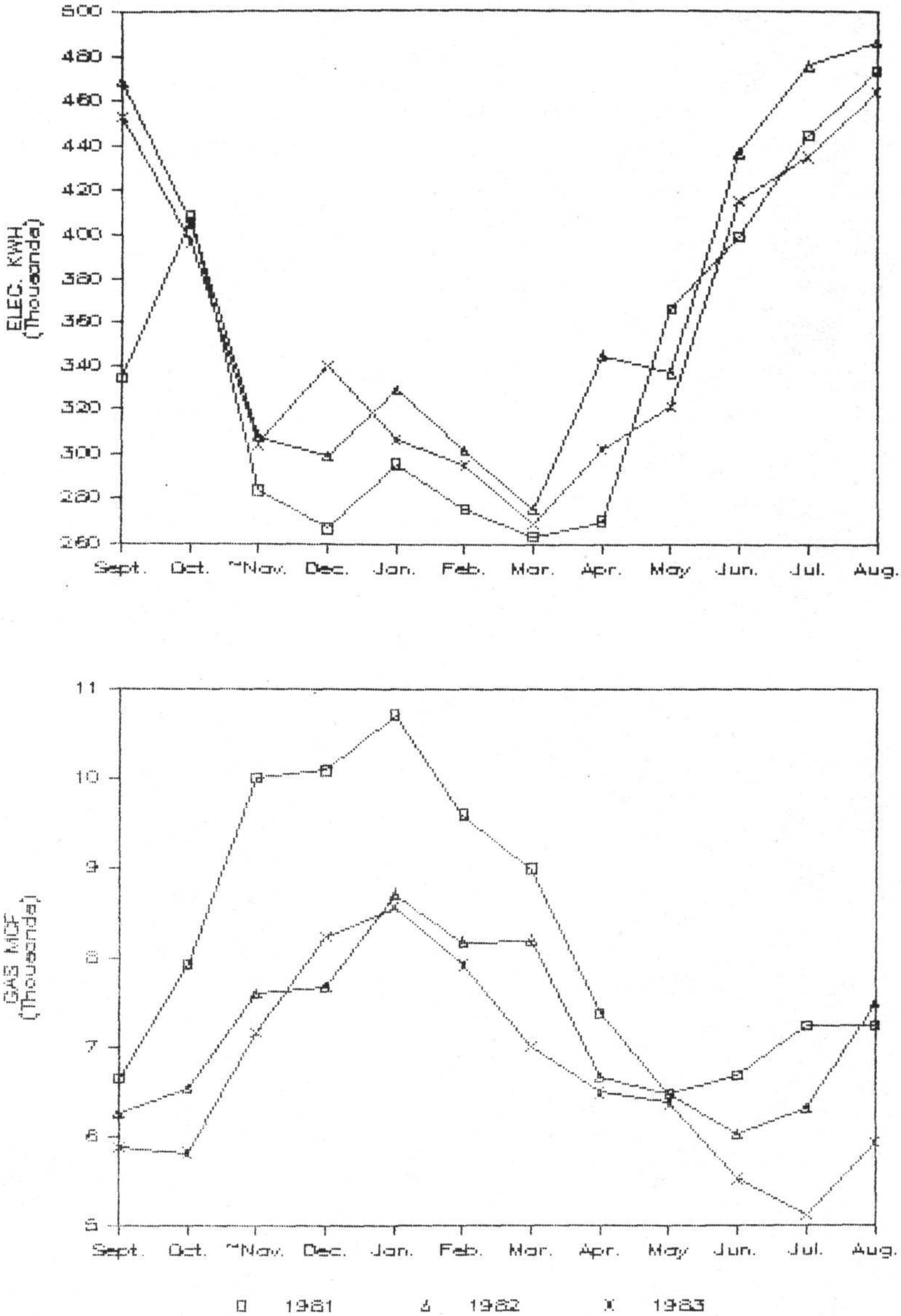


Figure C-54

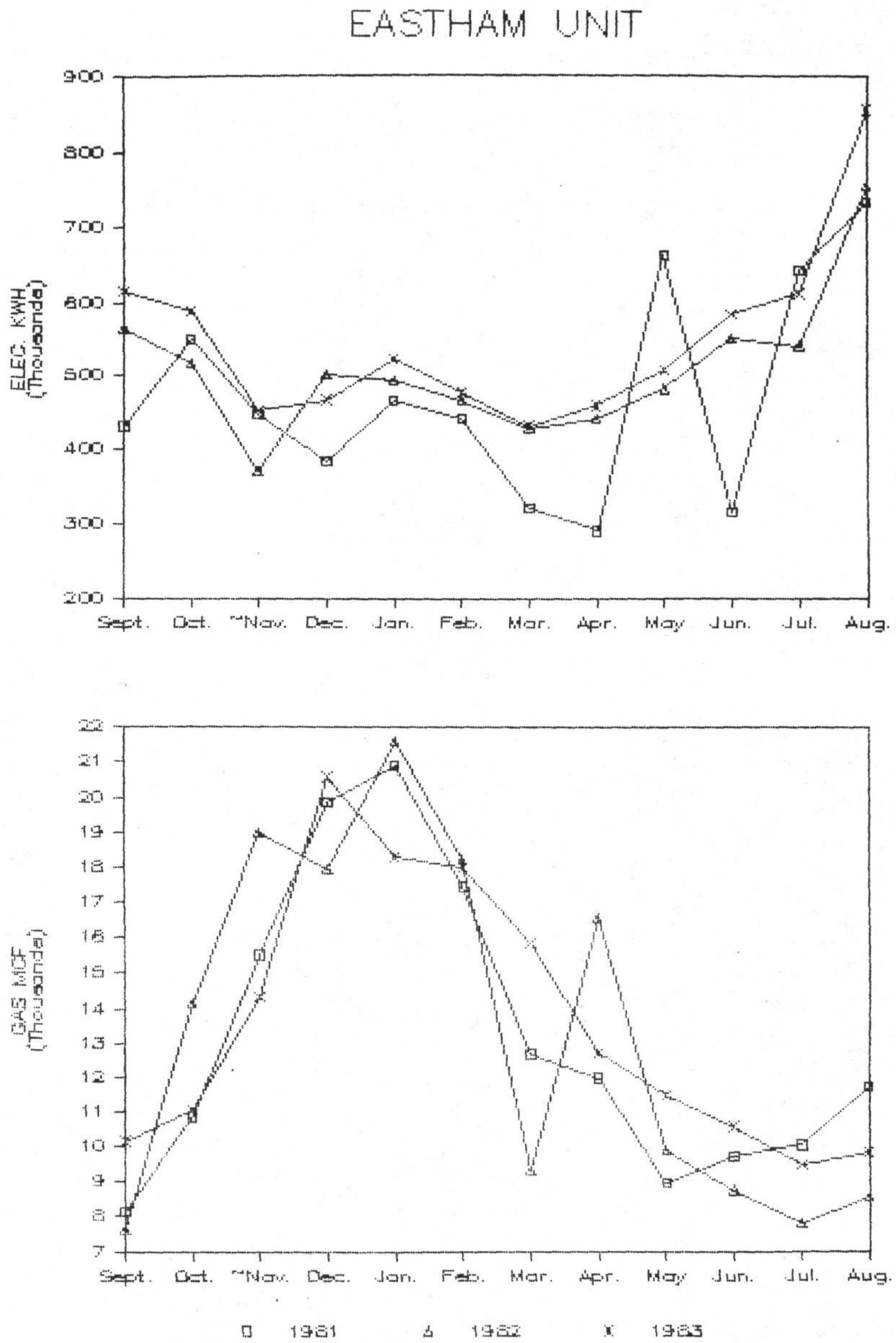

EASTHAM UNIT
900
800
700
600
500
400
300
200
ELEC. KWH (Thousands)
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
GAS MCF (Thousands)
1981
1982
1983

Figure C-55

RAMSEY UNIT

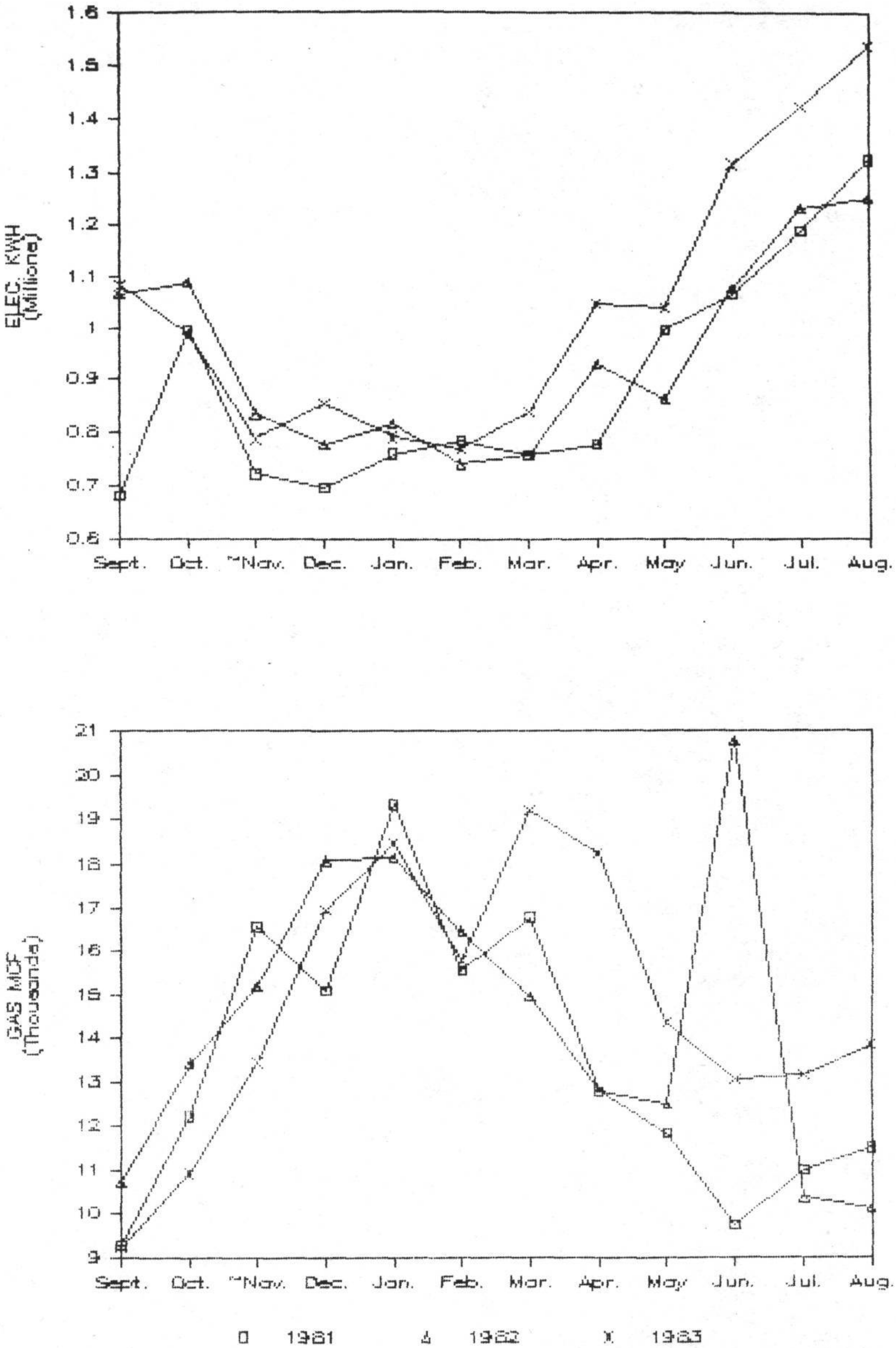


Figure C-56

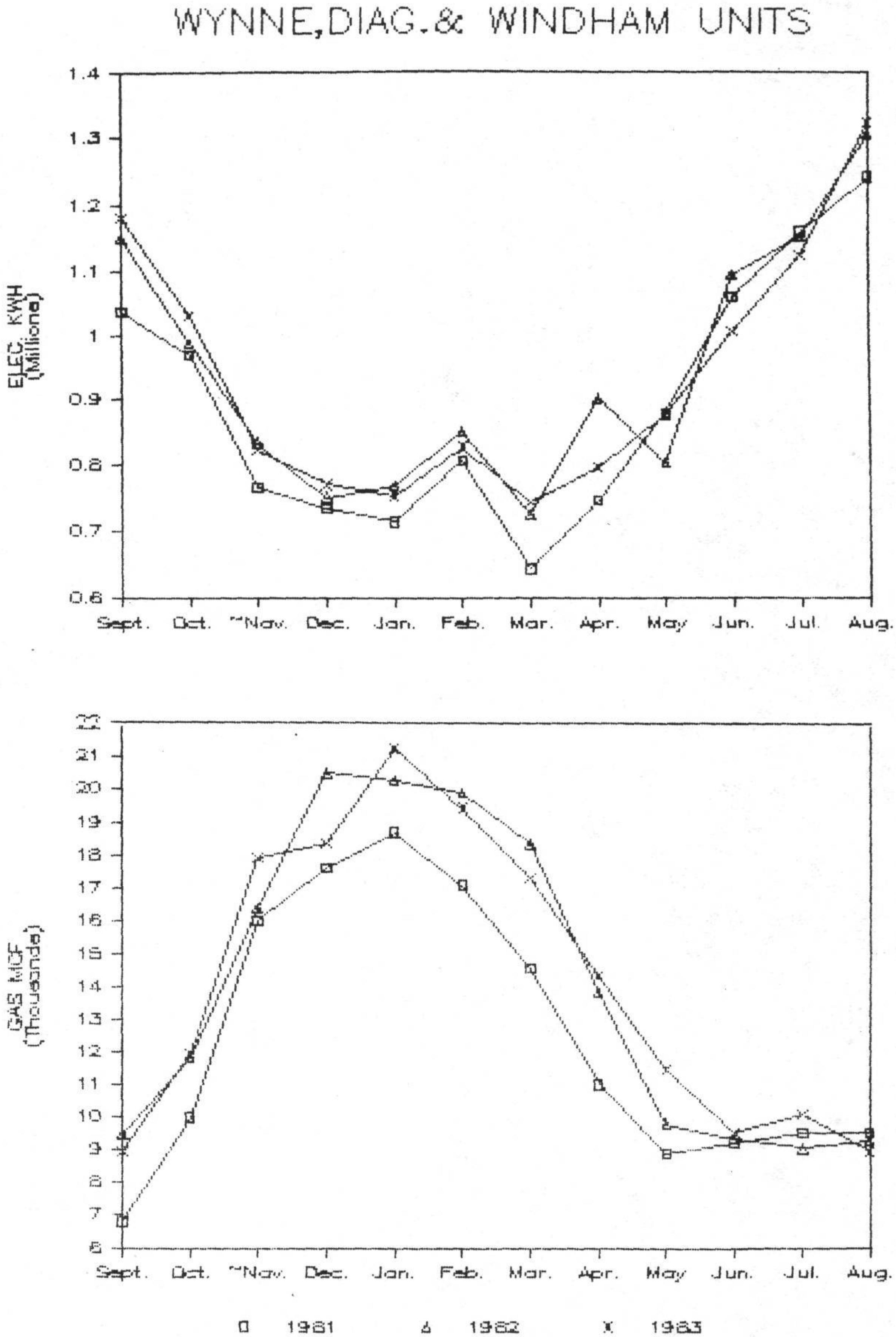

WYNNE,DIAG.& WINDHAM UNITS
ELEC. KWH (Millions)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
1981
1982
1983

Figure C-57

RETRIEVE UNIT

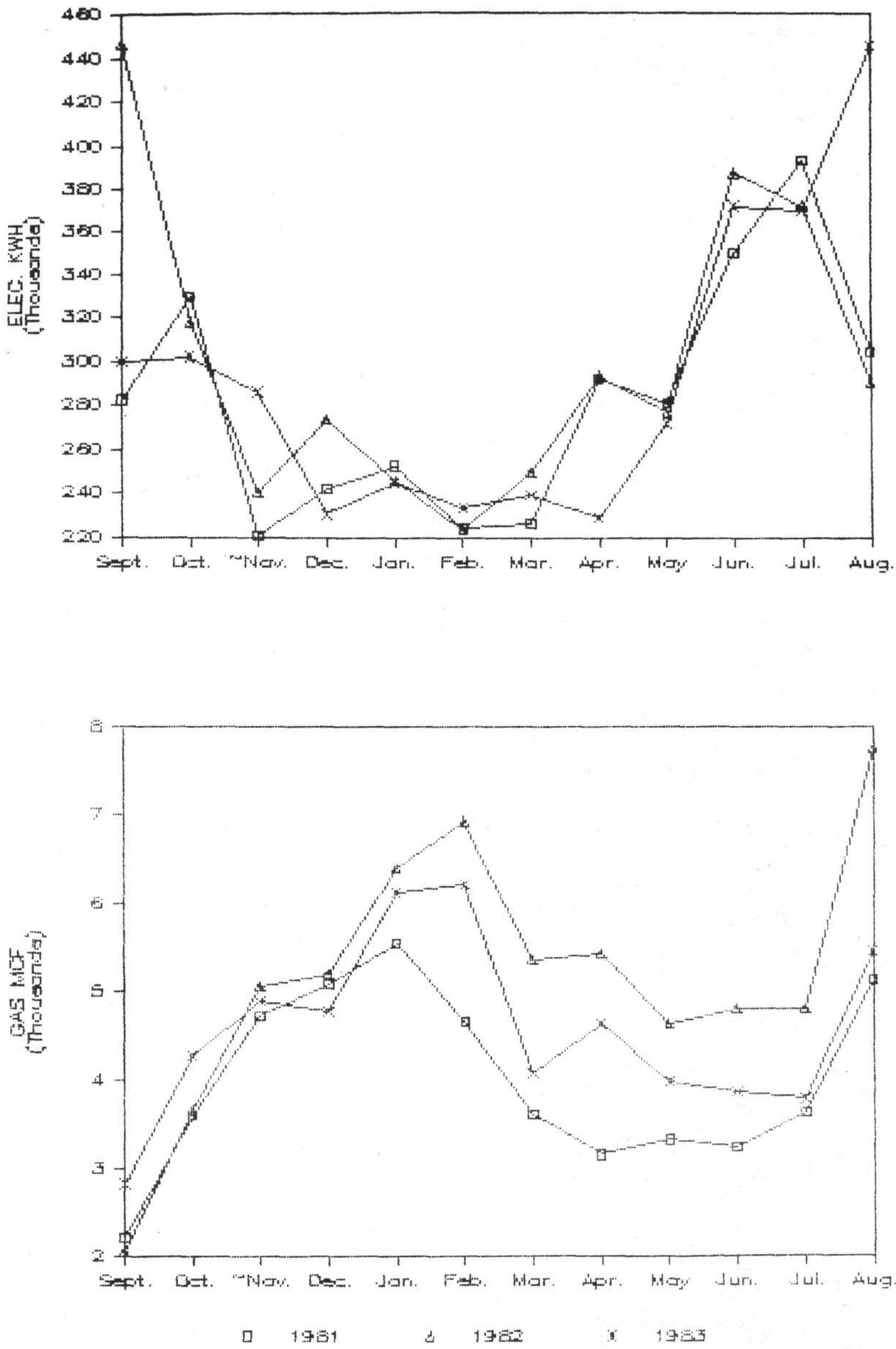


Figure C-58

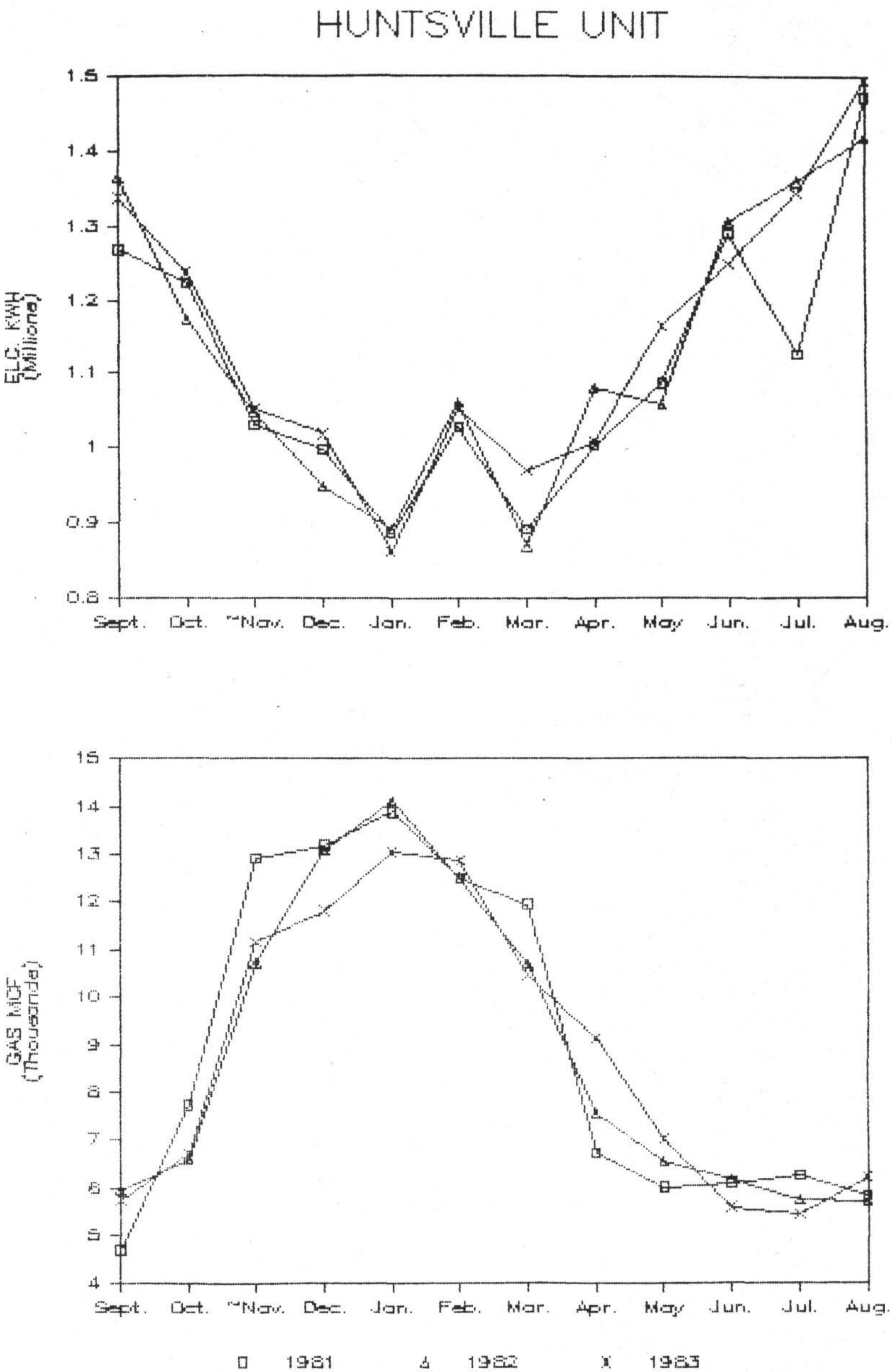
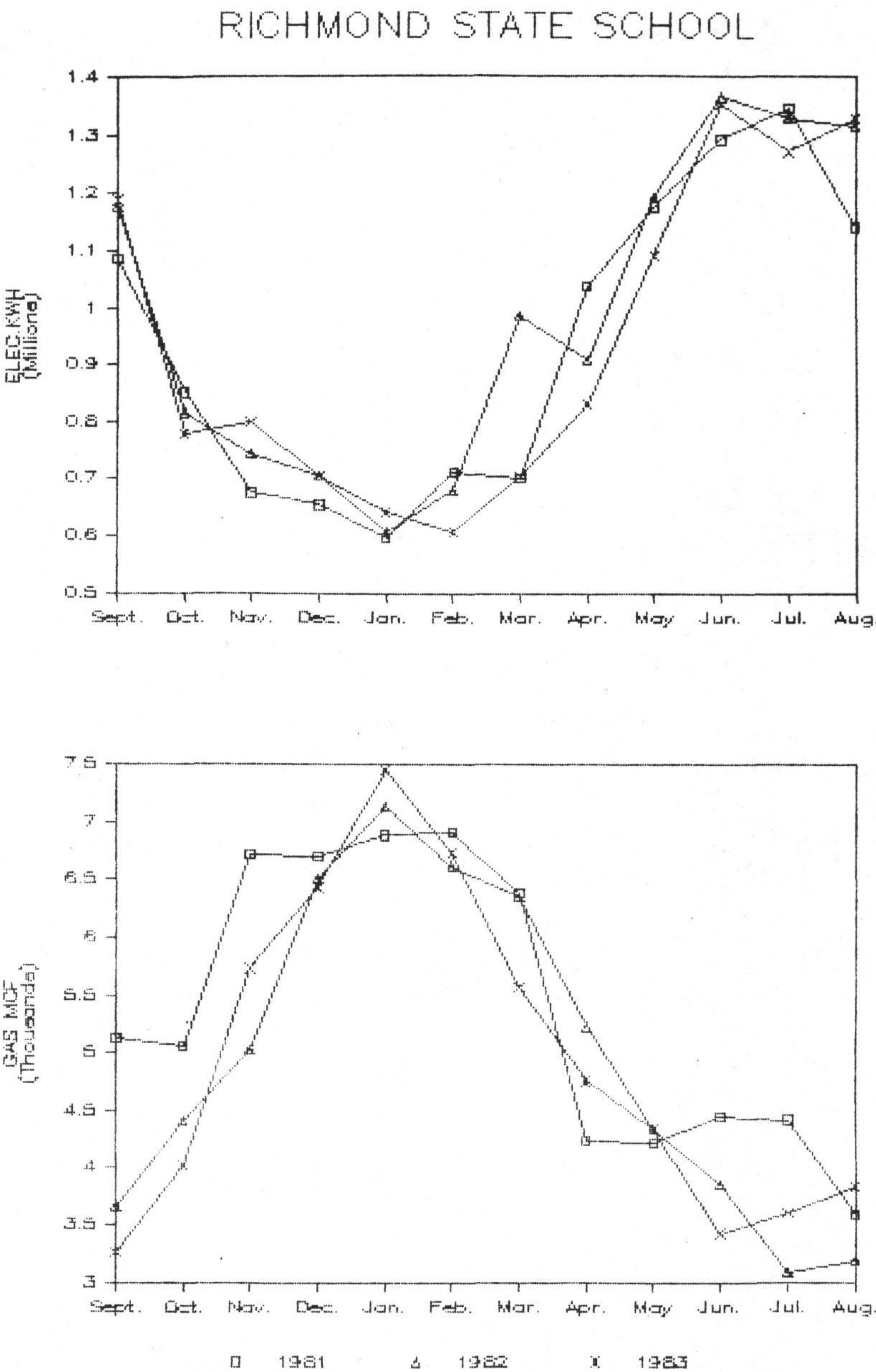

HUNTSVILLE UNIT
ELC. KWH (Millions)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
15
14
13
12
11
10
9
8
7
6
5
4
1981
1982
1983

Figure C-59



RICHMOND STATE SCHOOL
ELEC.KWH (Millions)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
1981
1982
1983

Figure C-60

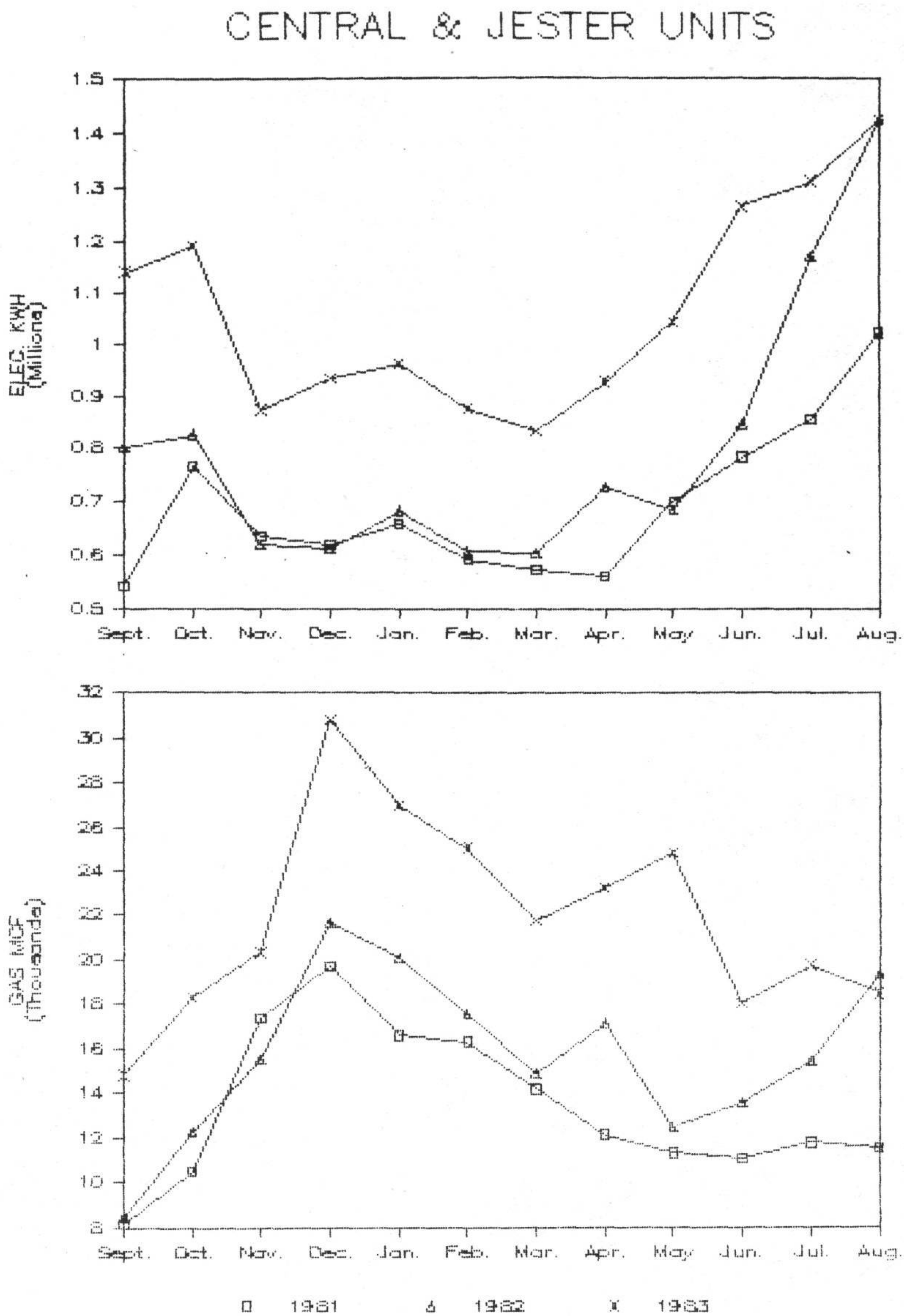

CENTRAL & JESTER UNITS
ELEC. KWH (Millions)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
GAS MCF (Thousands)
32
30
28
26
24
22
20
18
16
14
12
10
8
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
1981
1982
1983

Figure C-61

FERGUS ON UNIT

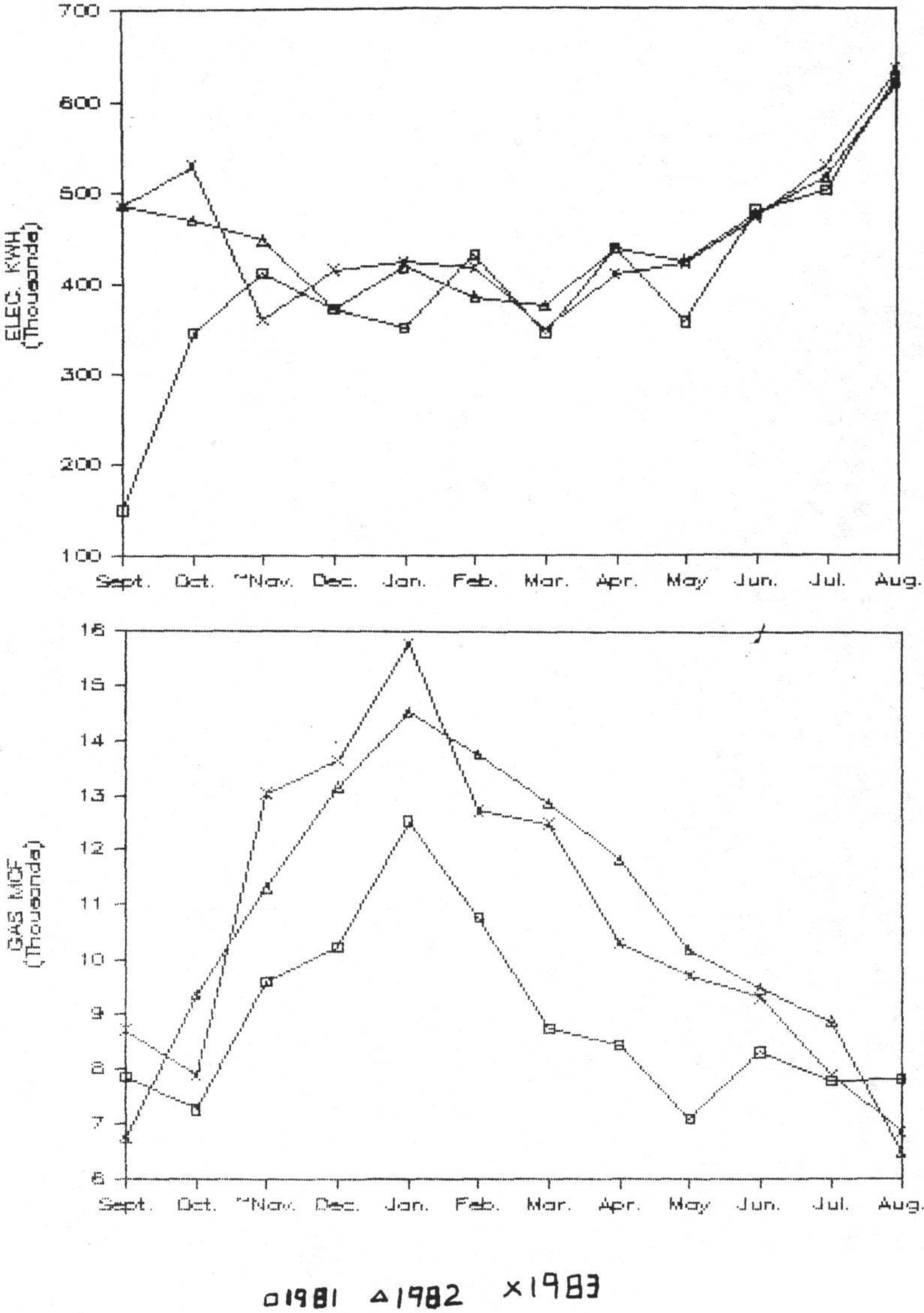


Figure C-62

STATE PURCHASING & GEN. SER. COMM.

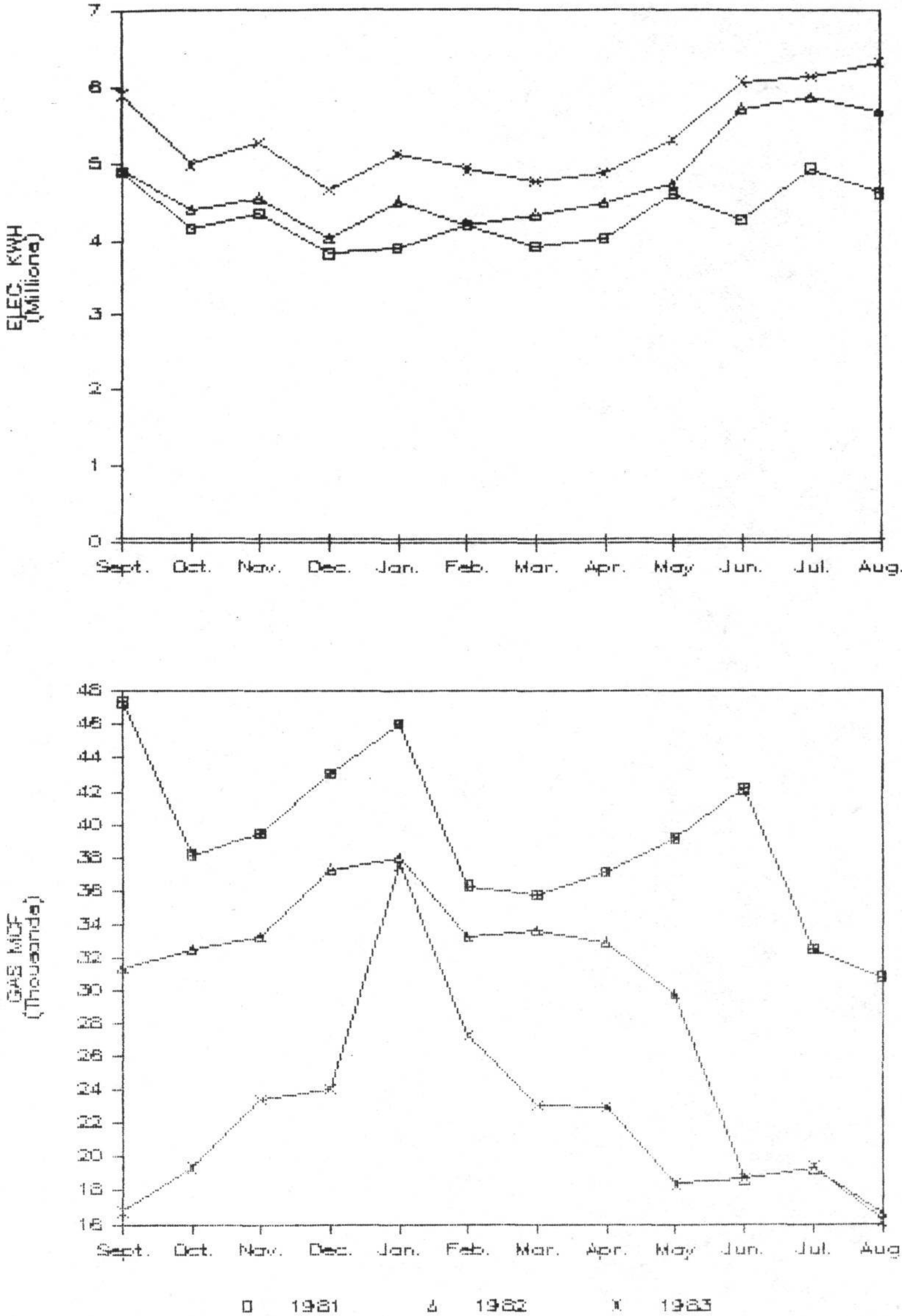


Figure C-63

TEXAS DEPT. OF HEALTH

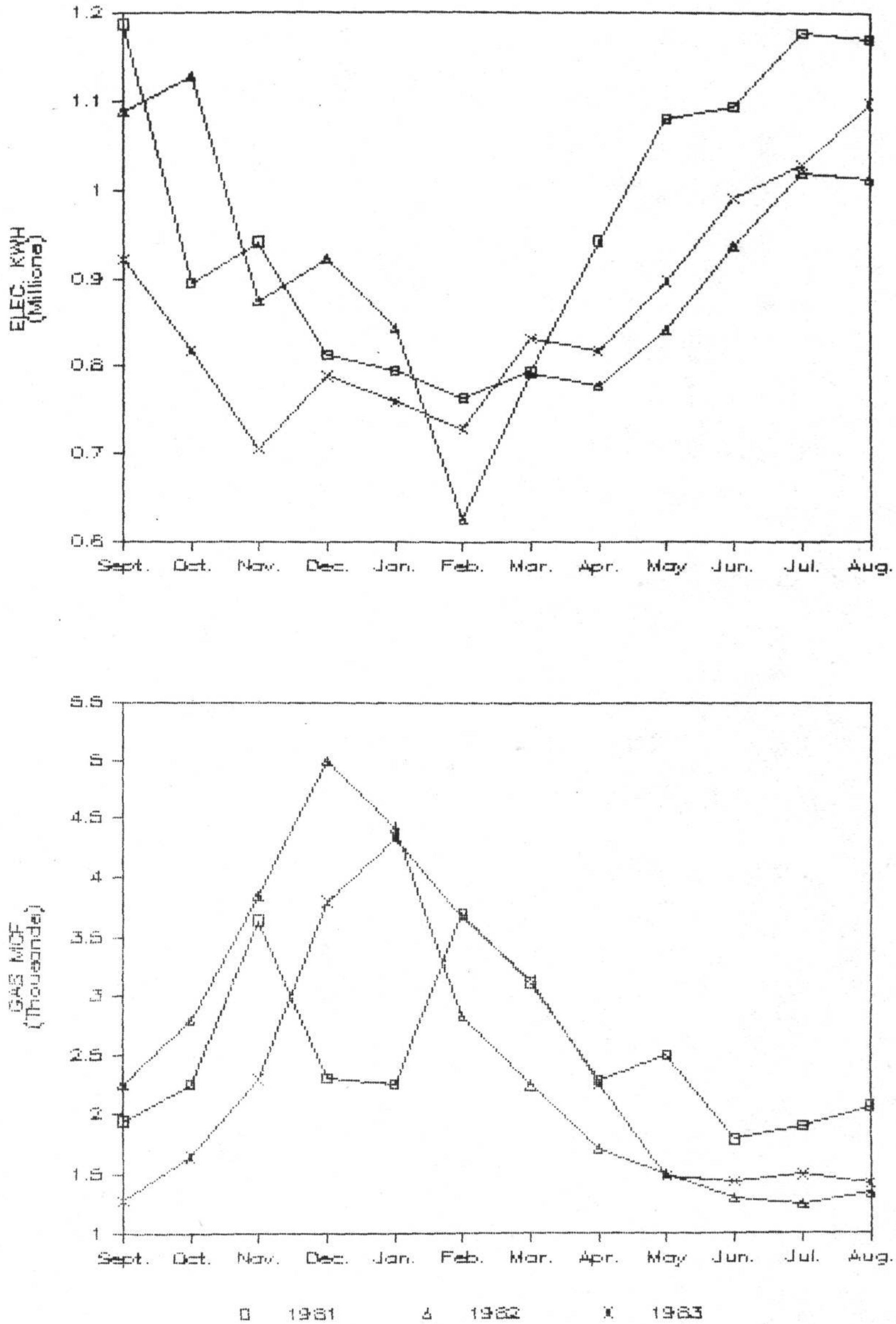


Figure C-64

ELLIS UNIT

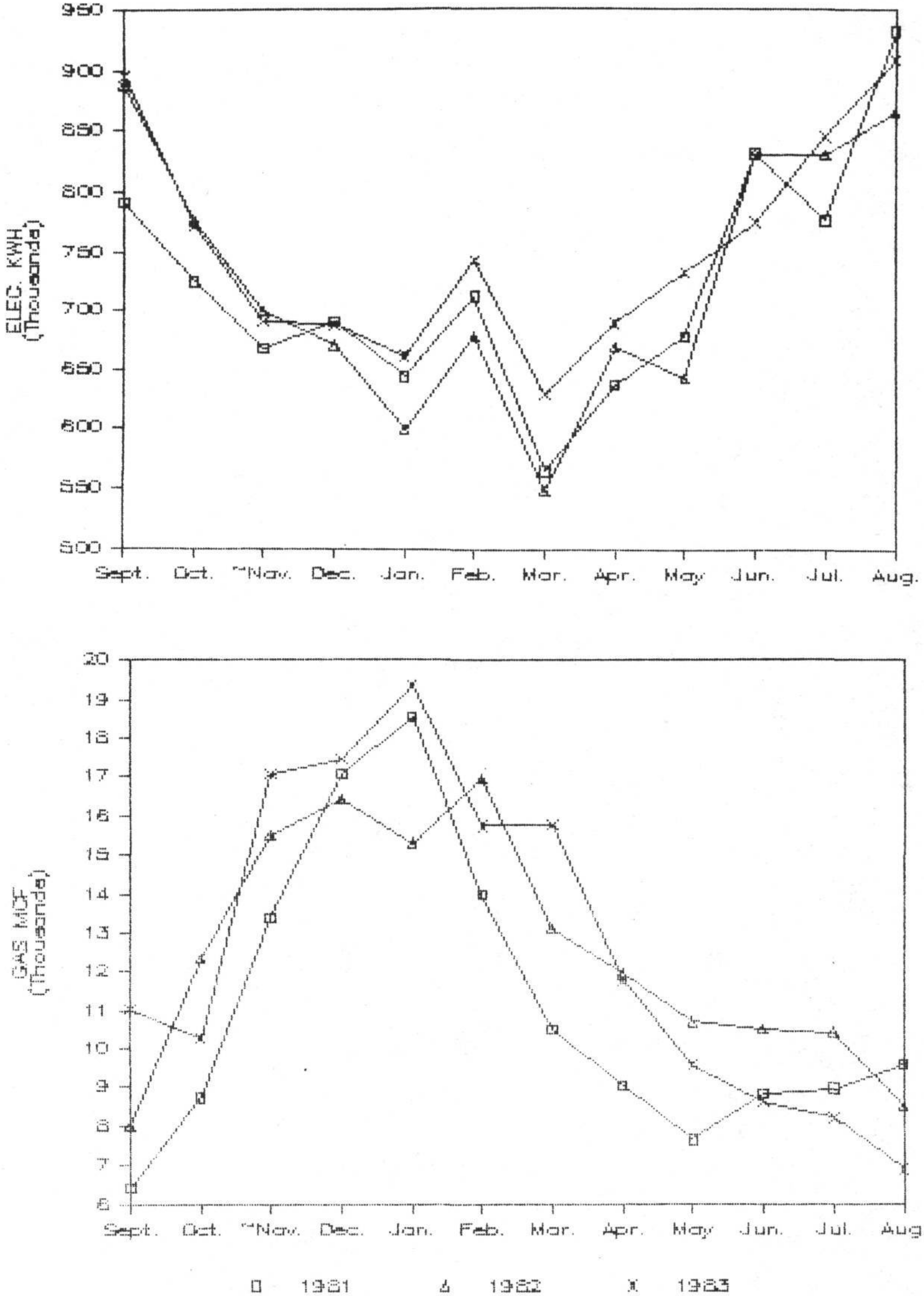


Figure C-65

DENTON STATE SCHOOL

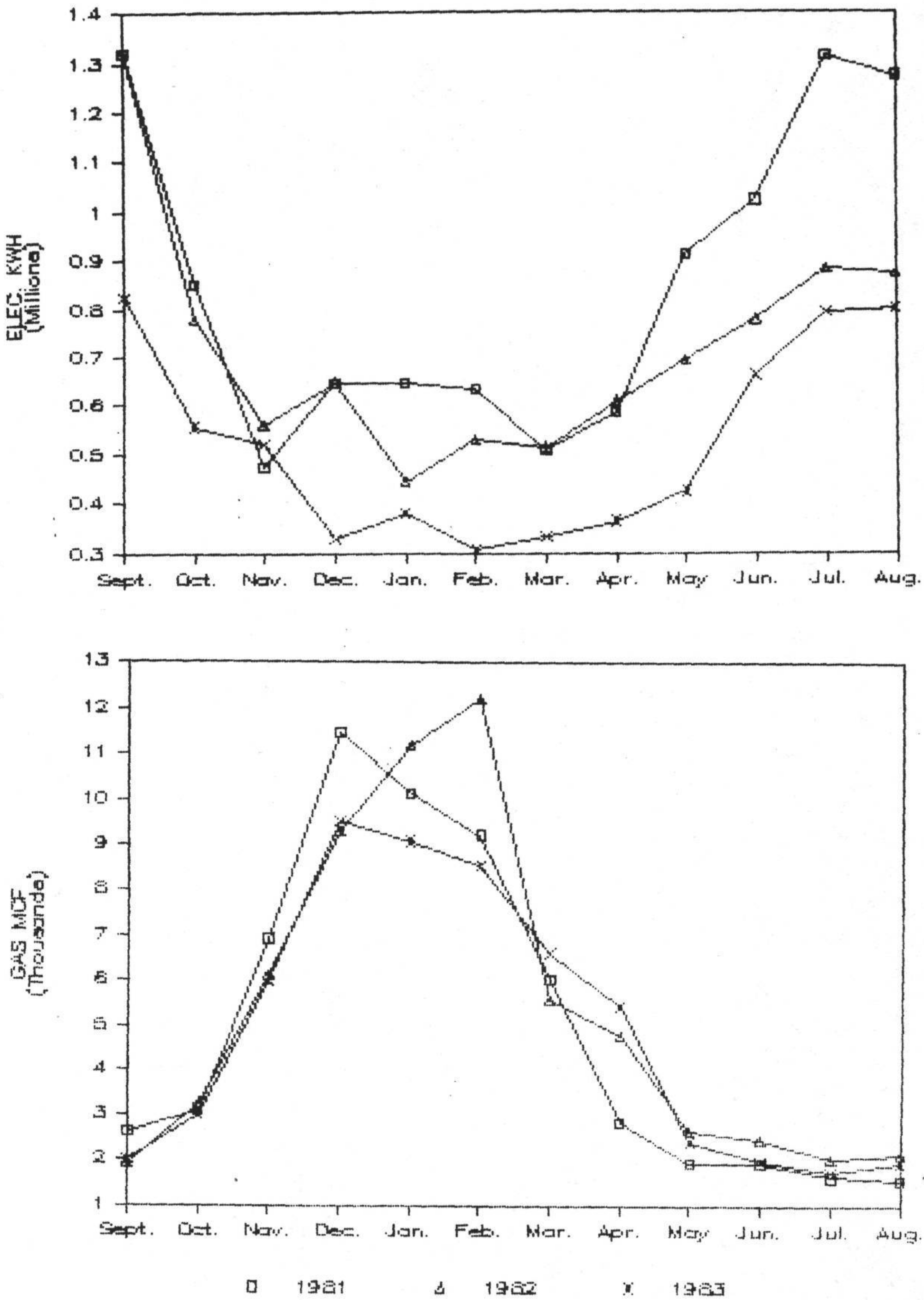
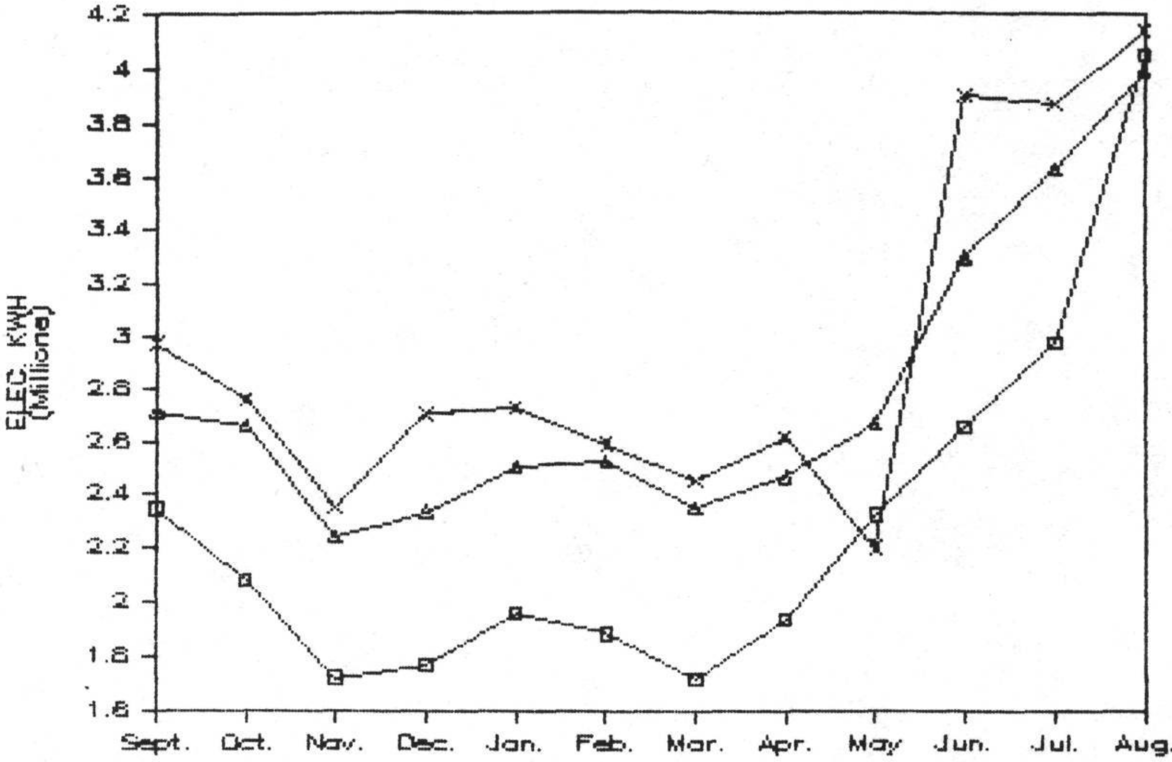


Figure C-66

TEXAS DEPT. OF HUMAN RESOURCES



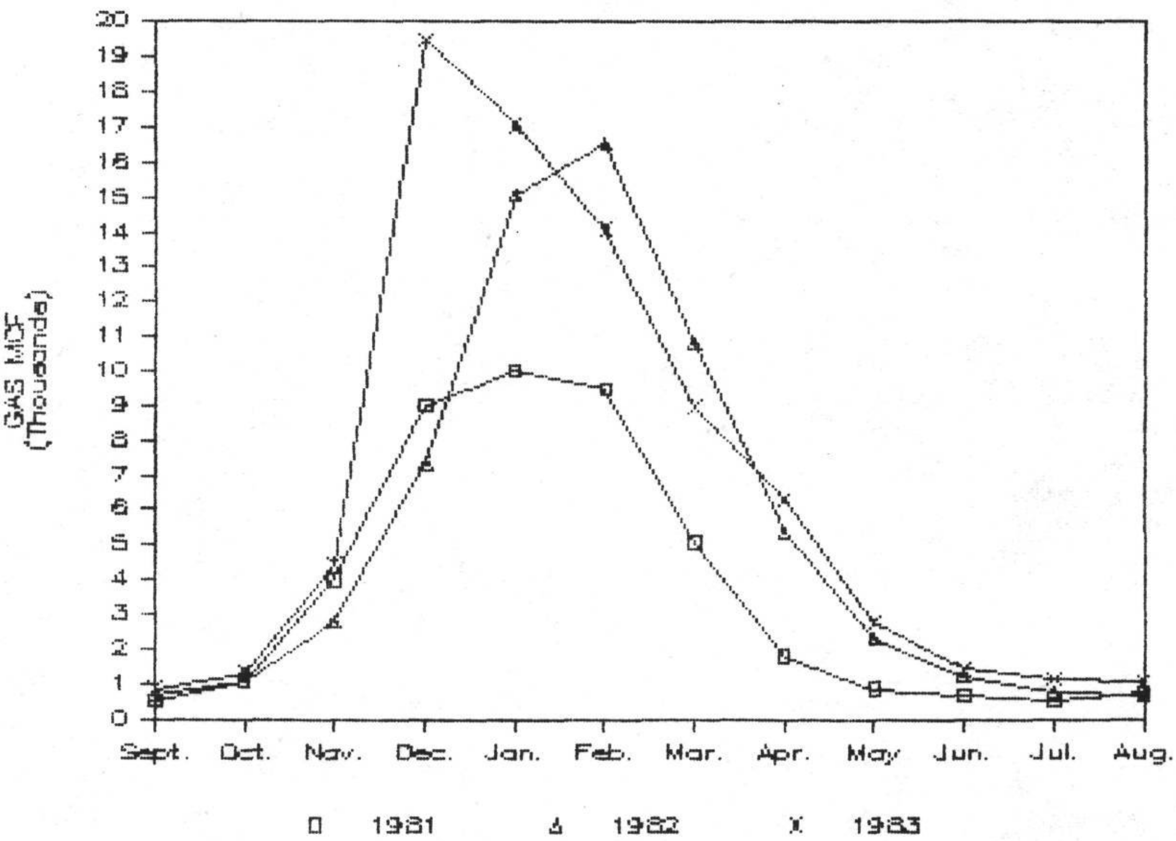
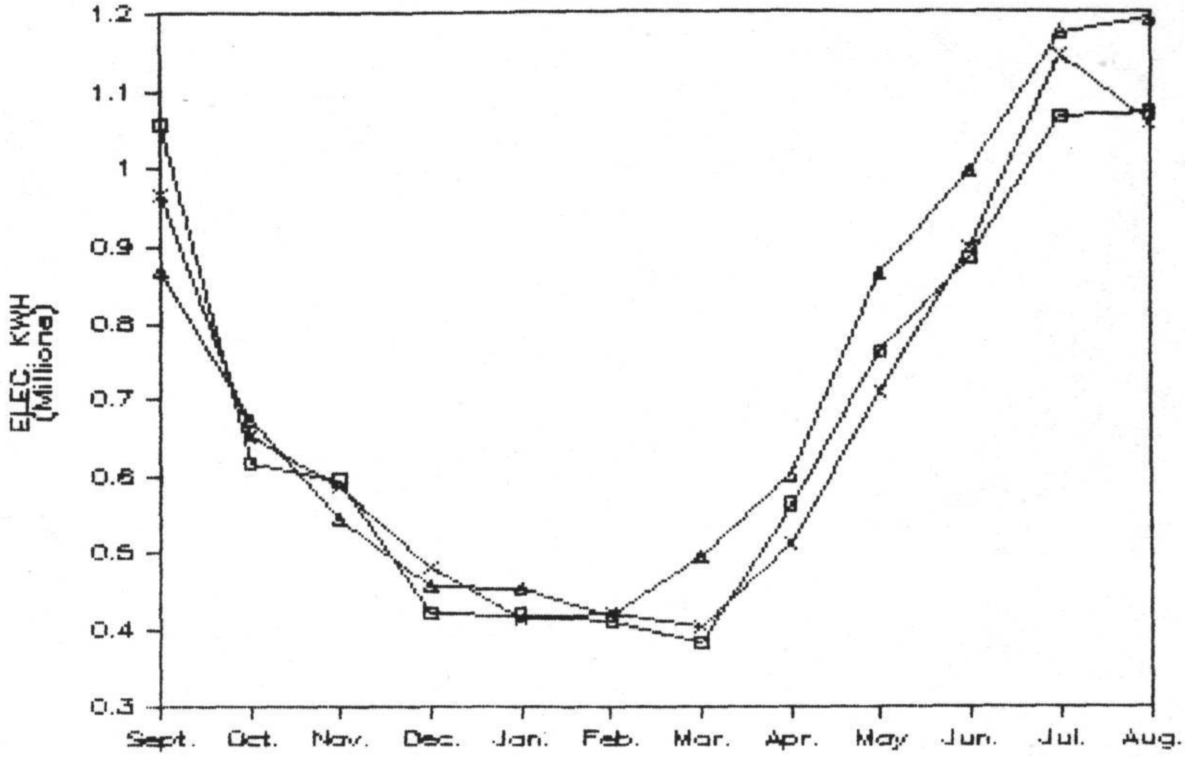


Figure C-67

AUSTIN STATE SCHOOL



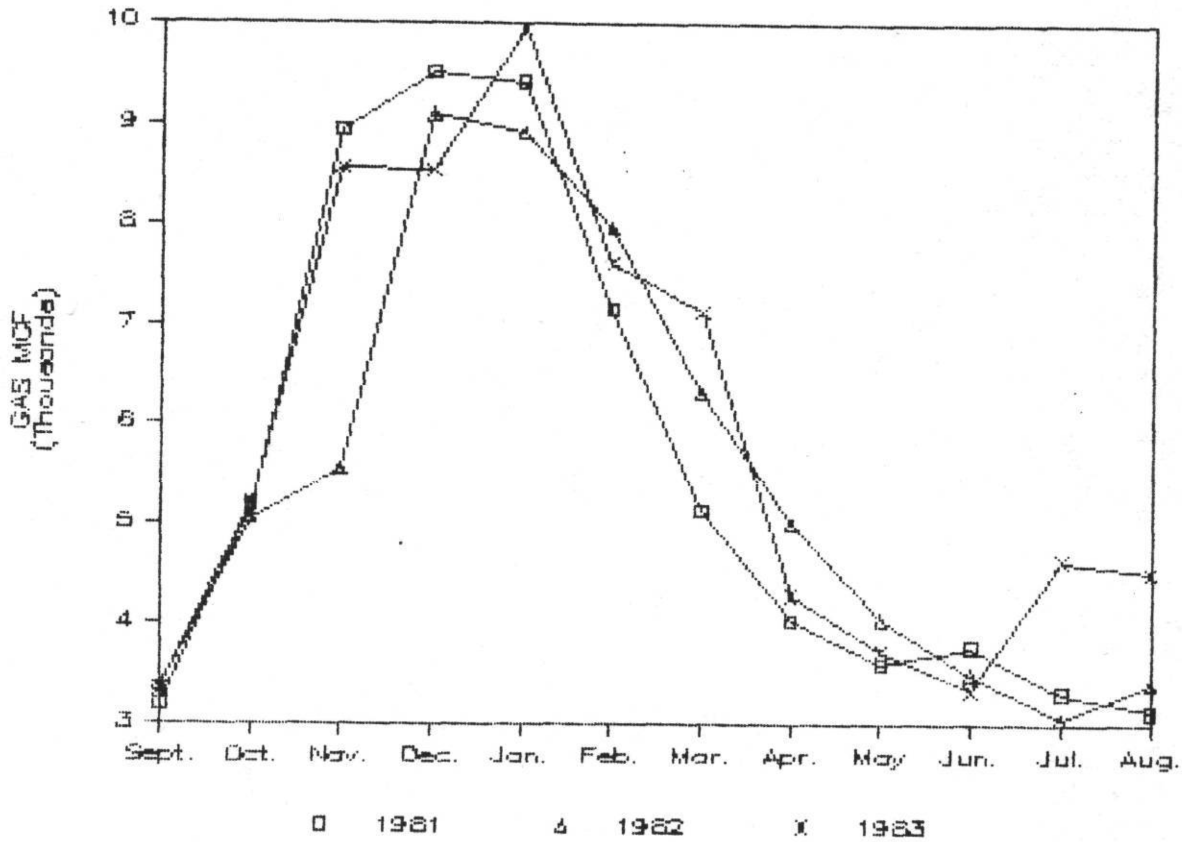
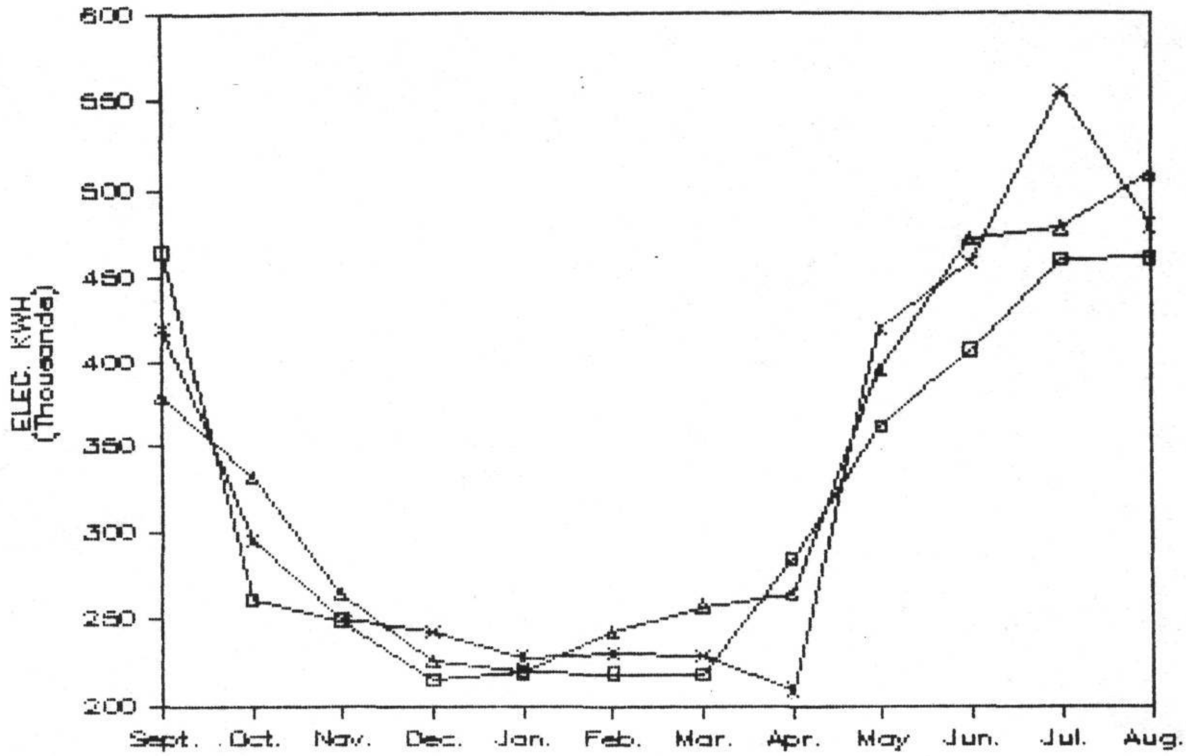


Figure C-68

ADJUTANT GENERAL'S DEPT.



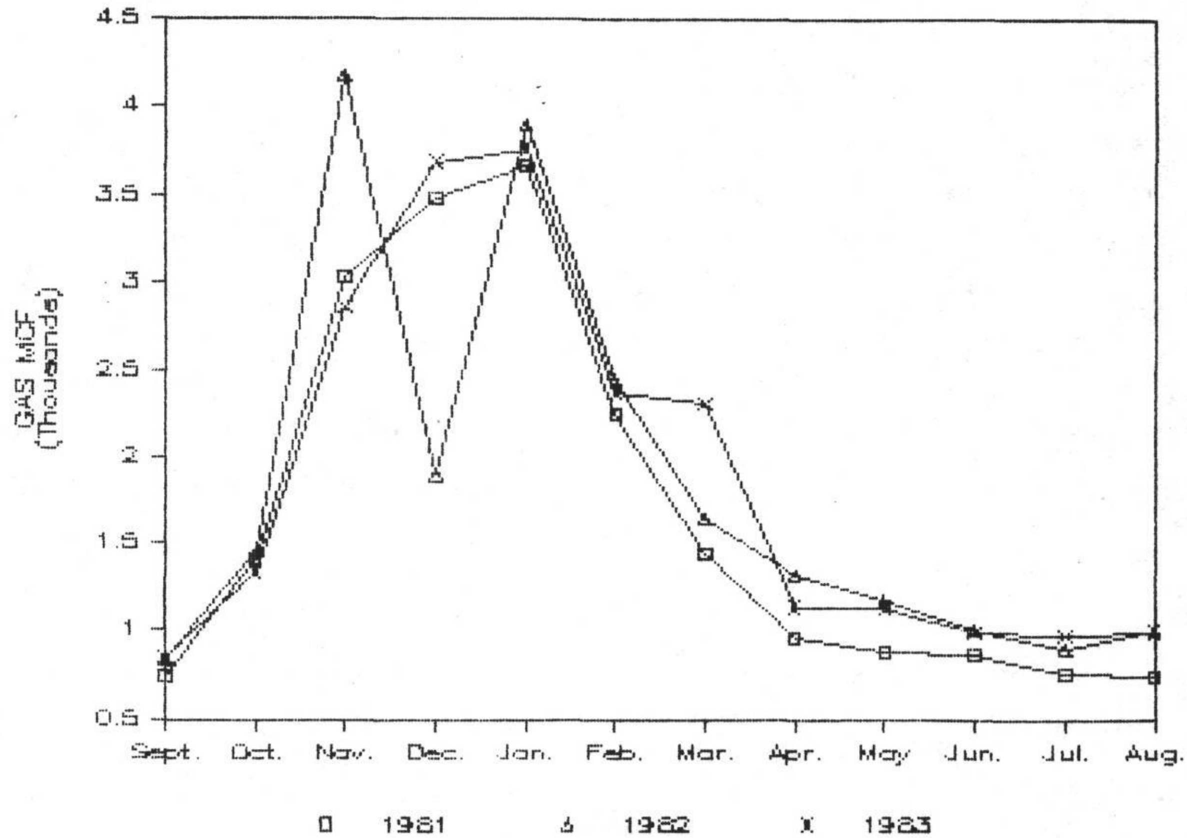
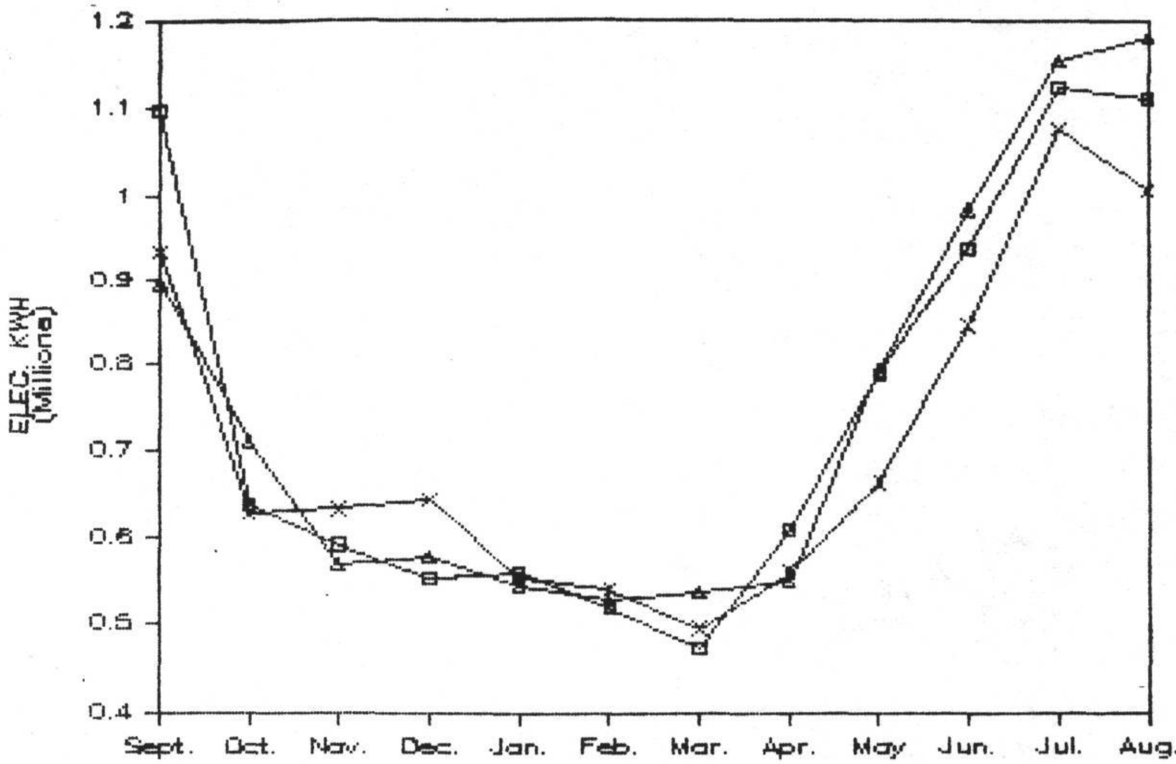


Figure C-69

TRAVIS STATE SCHOOL



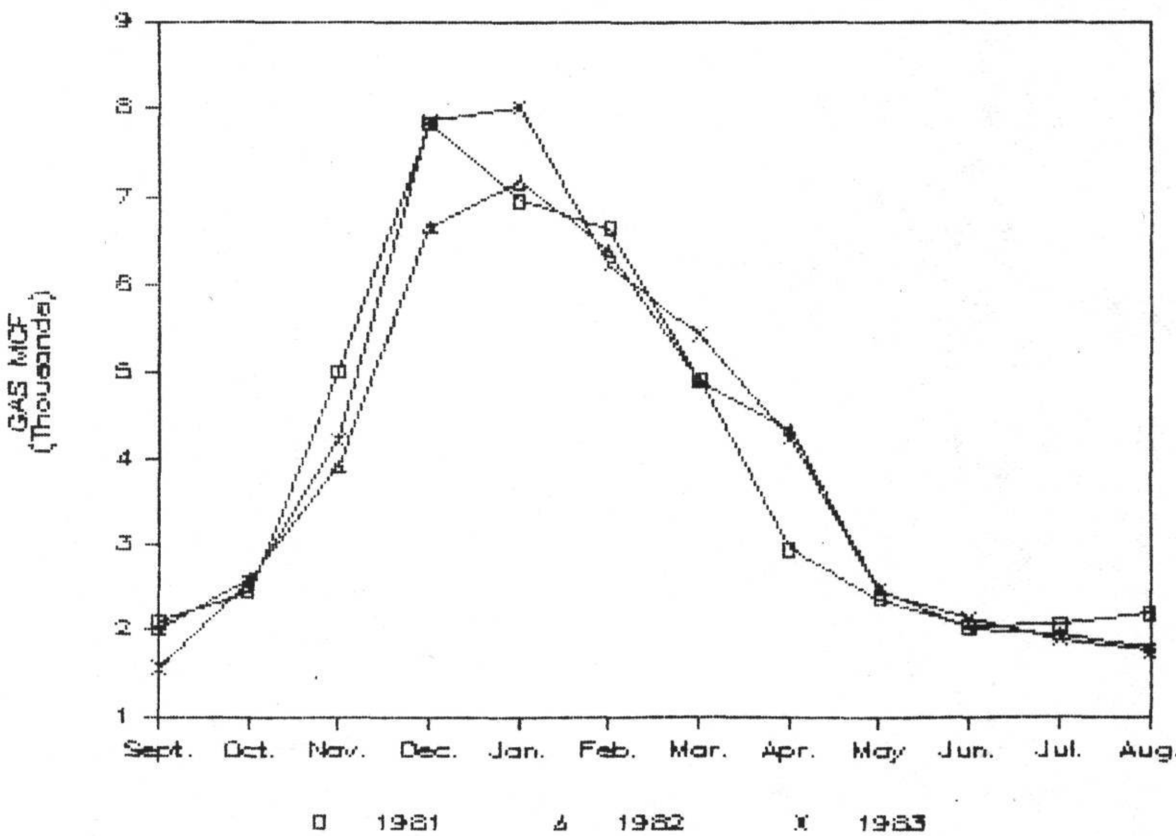
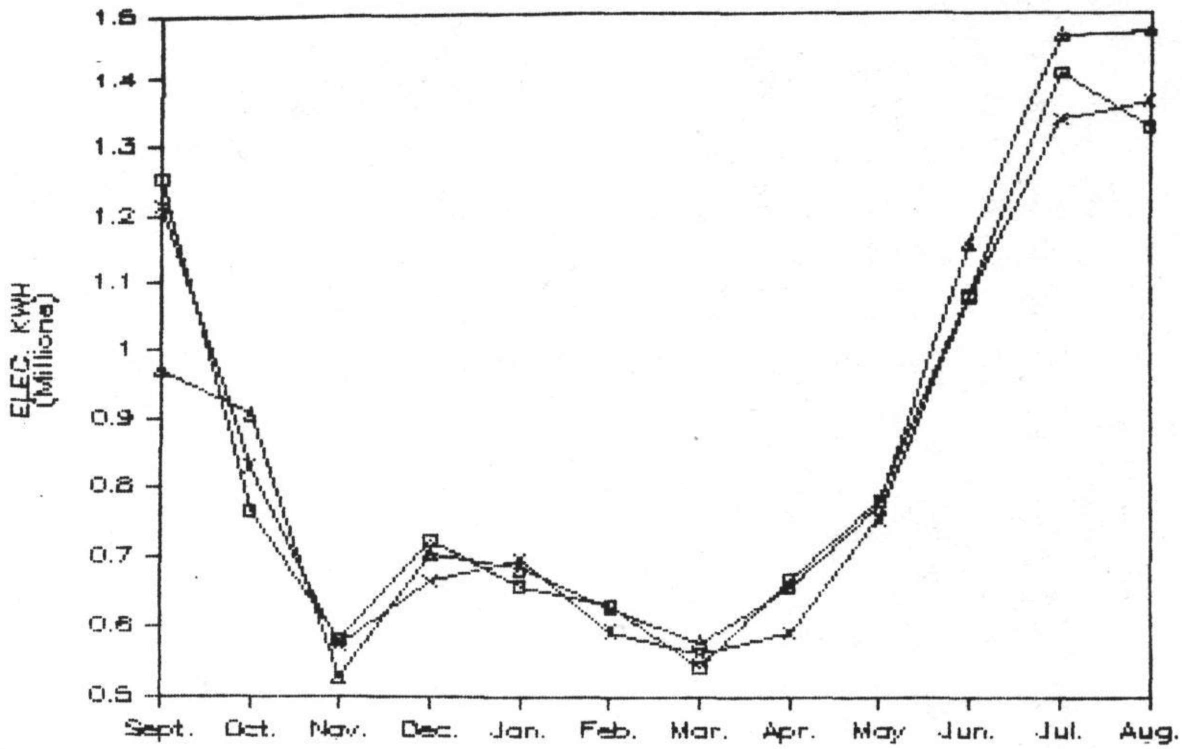
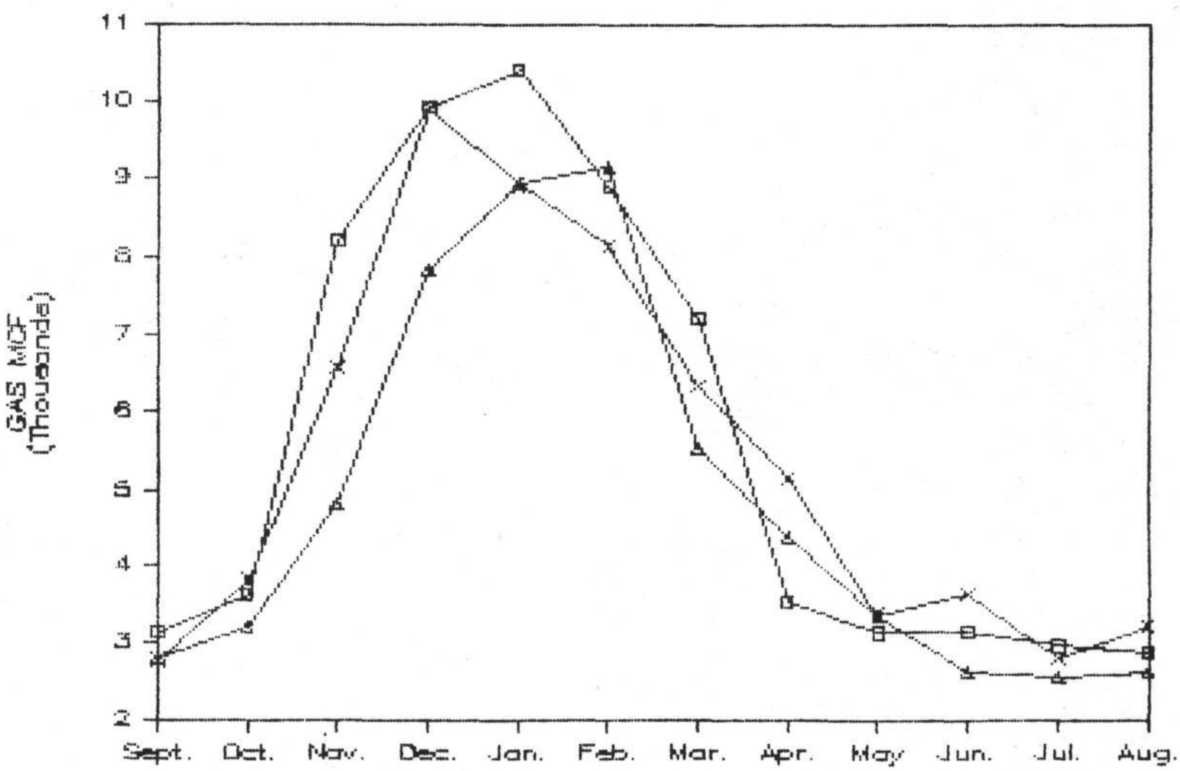


Figure C-70

MEXIA STATE SCHOOL

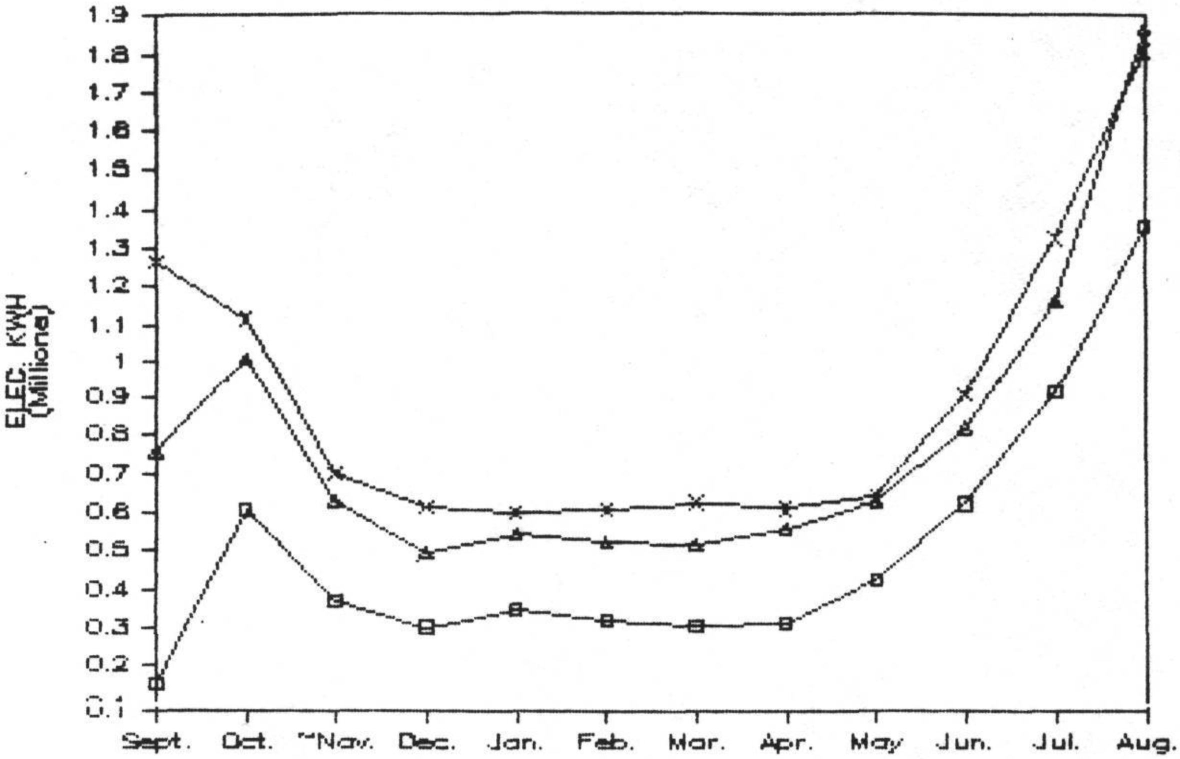




□ 1981 △ 1982 X 1983

Figure C-71

MT. VIEW, GATESVILLE UNITS



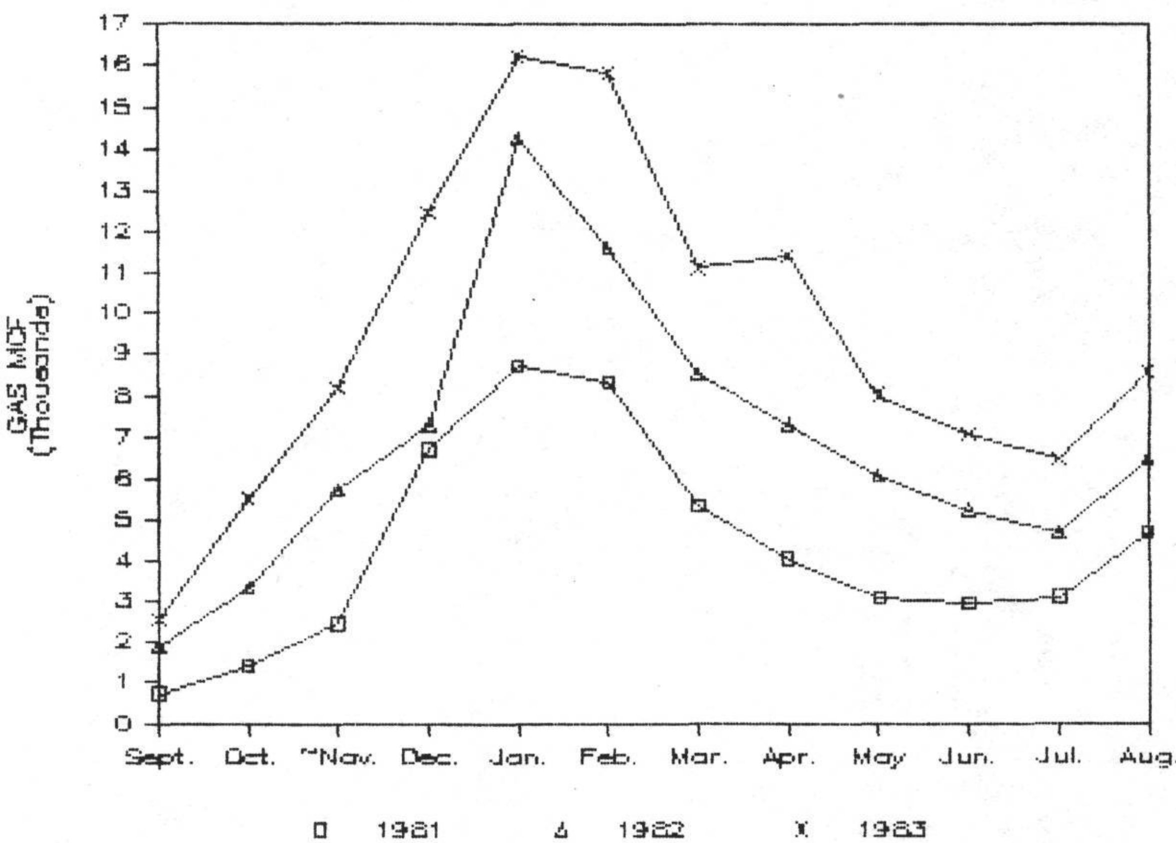


Figure C-72

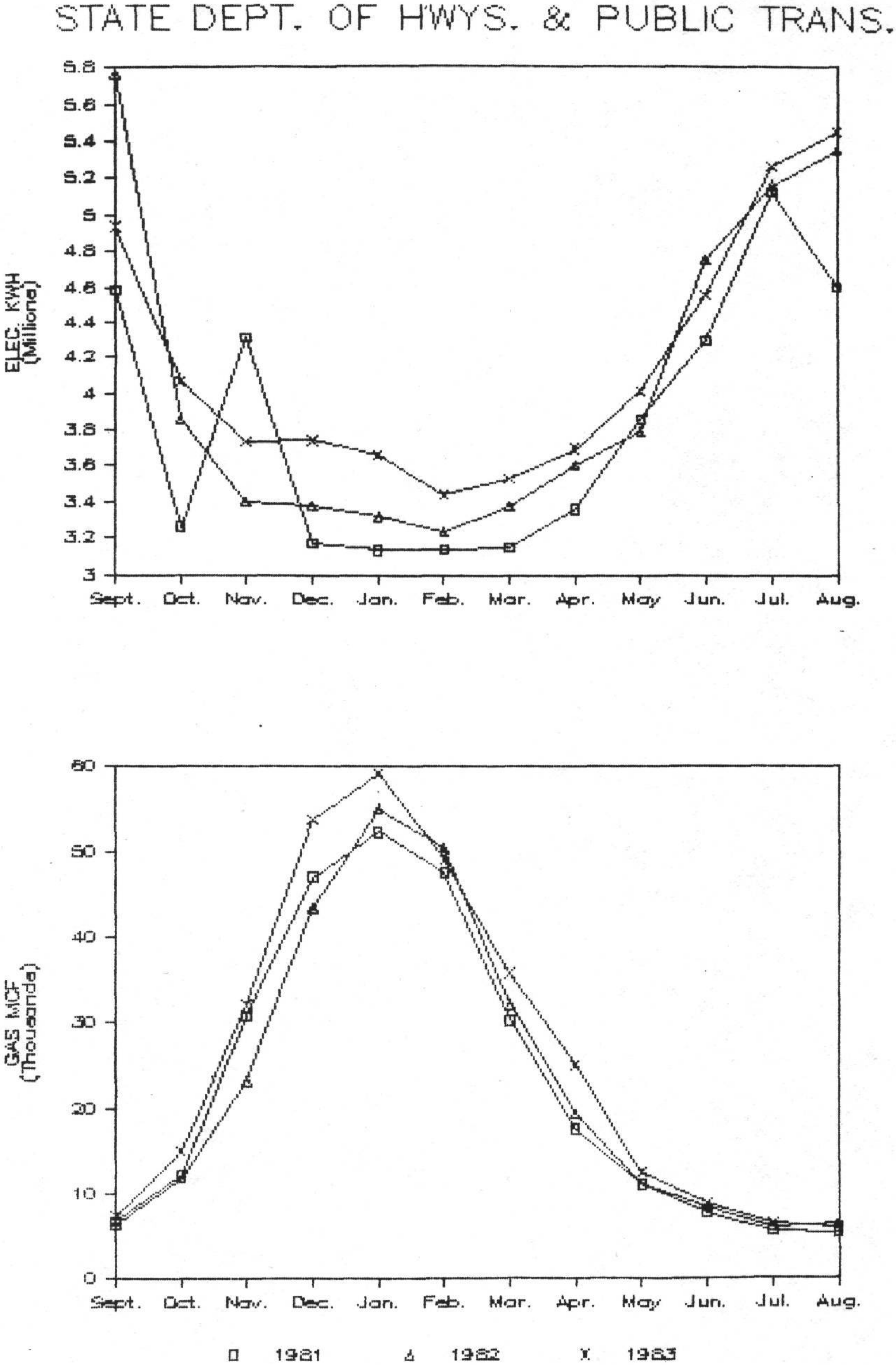

STATE DEPT. OF H'WYS. & PUBLIC TRANS.
ELEC. KWH (Millions)
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
GAS MCF (Thousands)
60
50
40
30
20
10
0
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
1981
1982
1983

Figure C-73

TEXAS EMPLOYMENT COMM.

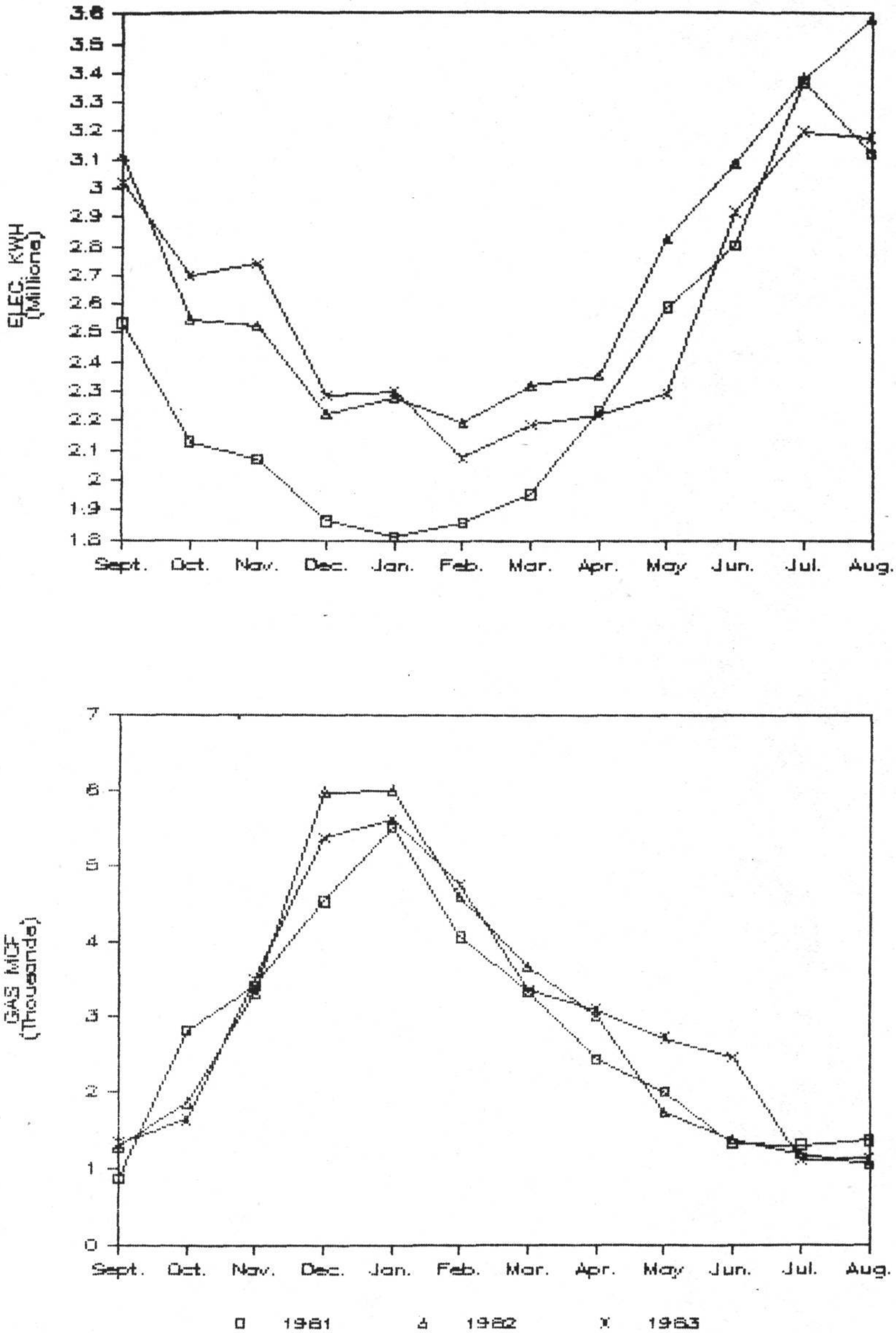


Figure C-74

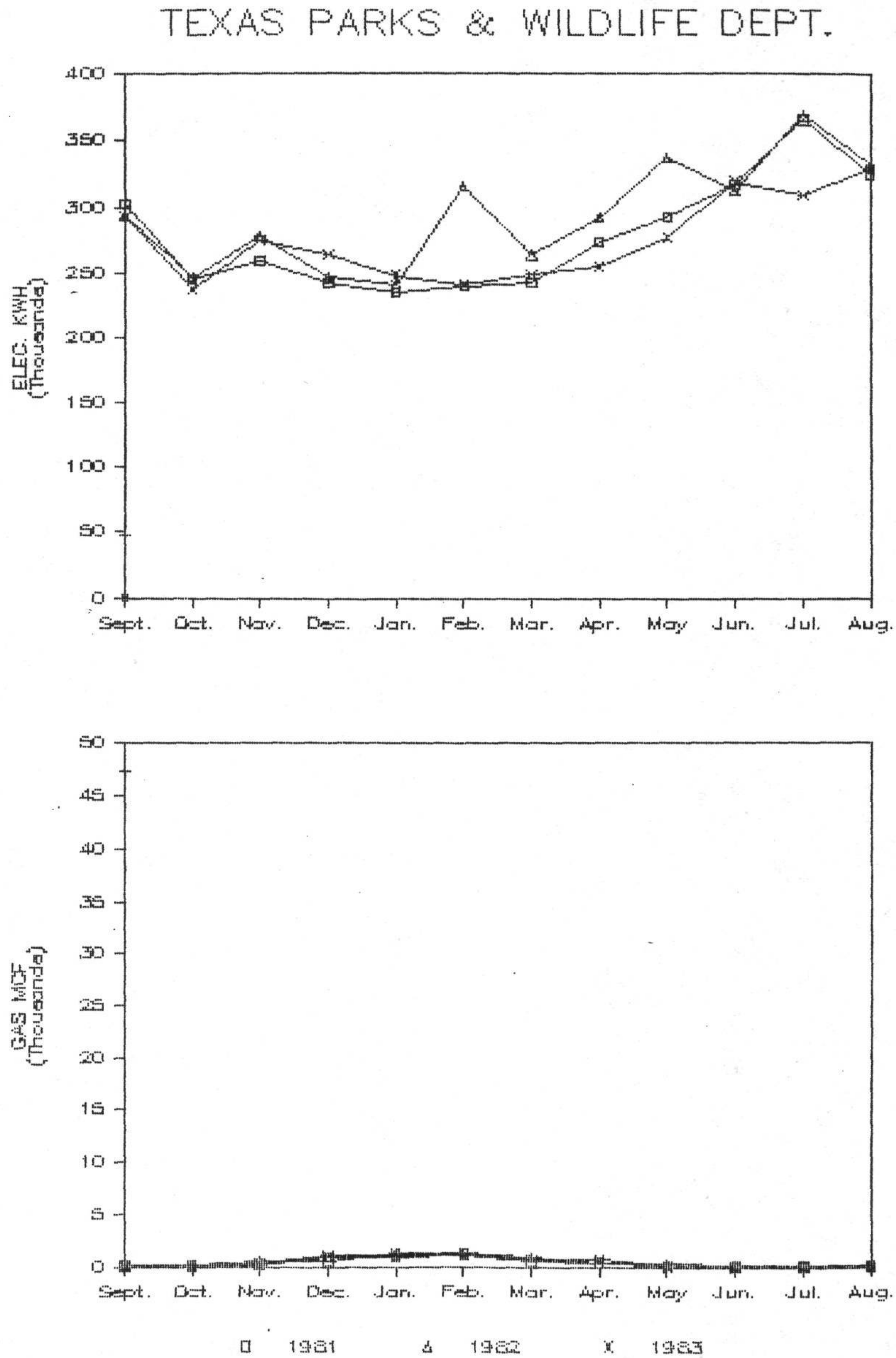
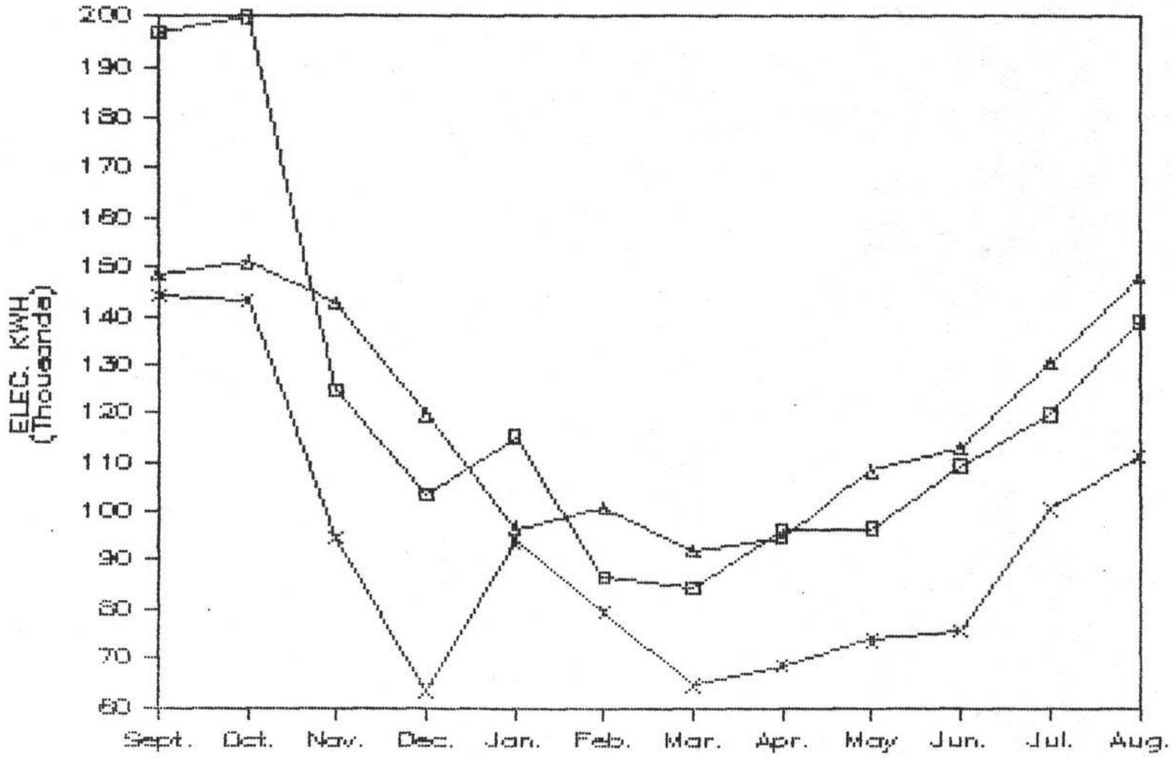

TEXAS PARKS & WILDLIFE DEPT.
ELEC. KWH (Thousands)
400
350
300
250
200
150
100
50
0
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
GAS MCF (Thousands)
50
45
40
35
30
25
20
15
10
5
0
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
□ 1981 △ 1982 X 1983

Figure C-75

TEXAS DEPT. OF COMMUNITY AFFAIRS



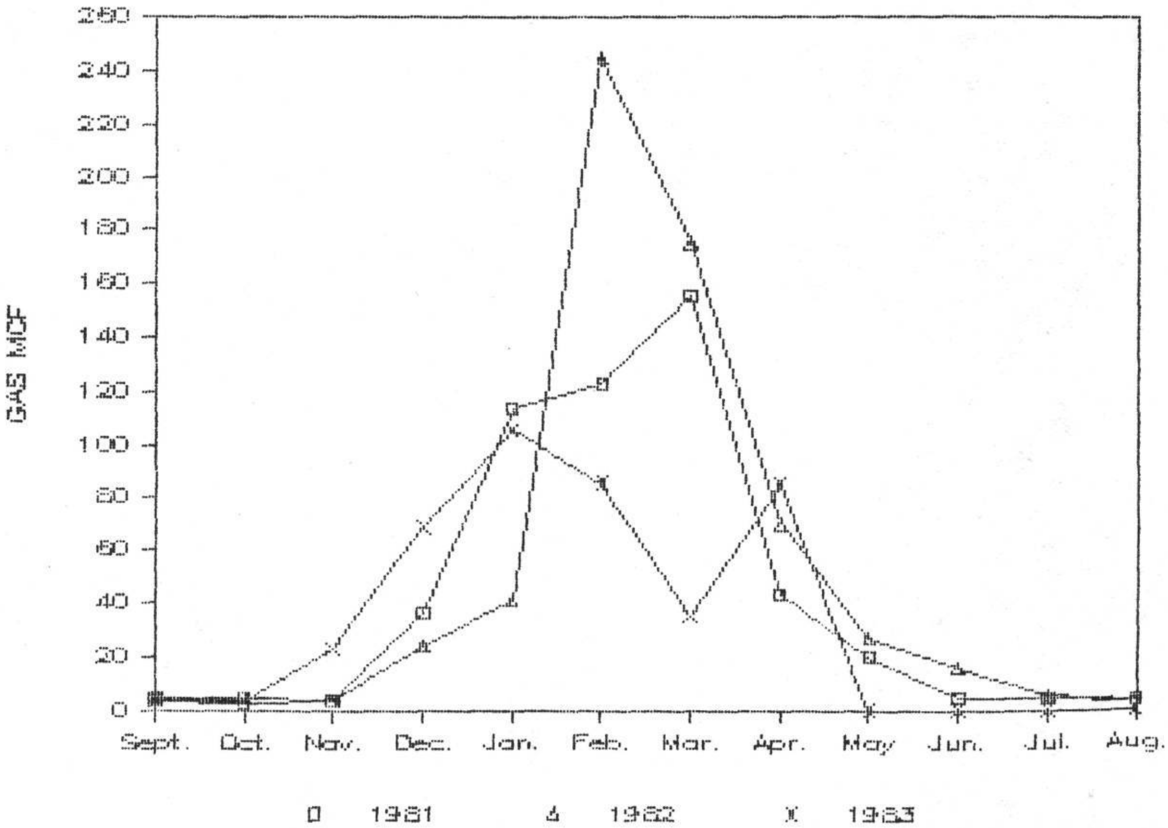


Figure C-76

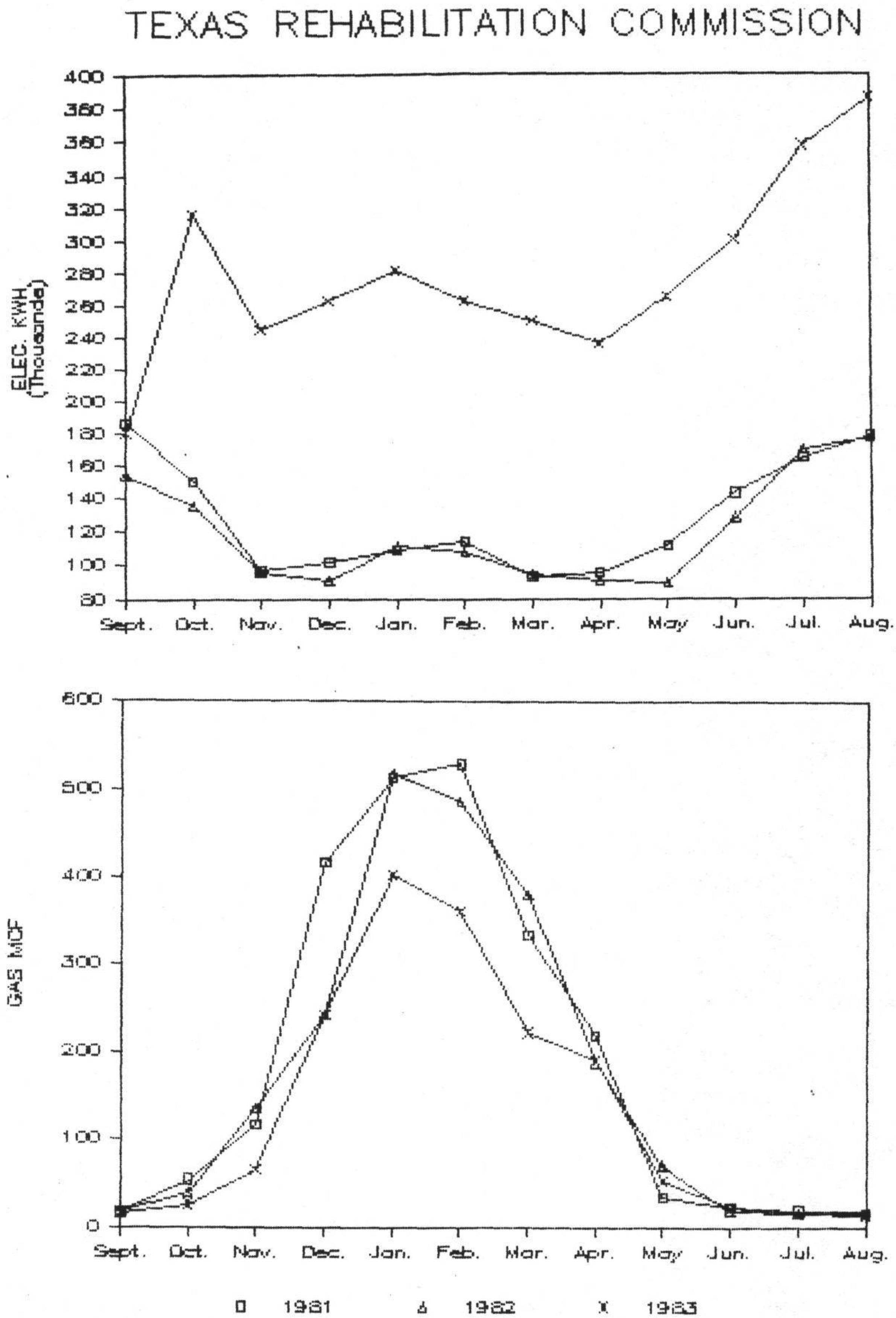

TEXAS REHABILITATION COMMISSION
ELEC. KWH
(Thousands)
GAS MCF
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug.
1981
1982
1983

Figure C-77

APPENDIX D

COPY OF STATE BUILDING STANDARDS LEGISLATION

AN ACT

relating to energy conservation in certain buildings and the responsibility and duties of the State Building Commission, the Governor's Energy Advisory Council, and other state agencies, commissions, and institutions; relating to energy conservation standards in buildings in home-rule cities; adding Subdivision 35 to Article 1175, Revised Civil Statutes of Texas, 1925, as amended; and declaring an emergency.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF TEXAS:

Section 1. SHORT TITLE. This Act may be cited as the Energy Conservation in Buildings Act.

Sec. 2. PURPOSE. The purpose of this Act is to provide for the development of improved design, lighting, insulation, and architectural standards to promote efficient energy use in state buildings including buildings of state-supported institutions of higher education, to reduce wasteful or uneconomic consumption of energy by balancing the cost of energy procurement against the cost of energy conserving building practices to achieve the minimum lifetime cost for all new state buildings, including new buildings of state-supported institutions of higher education, measured by combined construction and operating costs, and to provide information to the public relating to energy saving uses, designs, construction methods, and techniques for all new and existing buildings.

Sec. 3. ADOPTION AND PROMULGATION OF STANDARDS FOR STATE

BUILDINGS. (a) Within one year after the effective date of this Act, the State Building Commission, after consultation with the Governor's Energy Advisory Council, shall adopt and publish energy conservation design standards that all new state buildings, including buildings of state-supported institutions of higher education, are required to meet. These standards shall include both performance and procedural standards for maximum energy conservation allowed by the latest and most effective technology consistent with the requirements of public health and safety regulations and economic considerations.

(b) The standards shall be promulgated in terms of energy consumption allotments and shall take into consideration the various classes of building uses. Performance standards shall allow for design flexibility since only the total allotment of energy is prescribed.

(c) Procedural standards shall be directed toward specific design and building practices that produce good thermal resistance and low air leakage and toward requiring practices in the design of mechanical and electrical systems which conserve energy. The procedural standards shall address, when applicable, the following items:

(1) insulation,

(2) lighting, according to the lighting necessary for the tasks for which each area is intended to be used,

(3) ventilation,

(4) the potential use of new systems for saving

energy in ventilation, climate control, and other areas, and

(5) any other item which the State Building Commission deems appropriate.

Sec. 4. DESIGN STANDARDS BY OTHER ENTITIES. (a) The boards of regents and boards or governing bodies of state agencies, commissions, and institutions exempted under the State Building Construction Administration Act (Article 678f, Vernon's Texas Civil Statutes), shall adopt and publish energy conservation design standards as provided in Section 3 of this Act for all new buildings under their authority. The standards shall be consistent with those promulgated by the State Building Commission for other state buildings and be prepared in cooperation and consultation with the State Building Commission and the Governor's Energy Advisory Council.

(b) The State Building Commission shall assist the boards and governing bodies of state agencies, commissions, and institutions subject to the provisions of Subsection (a) of this section with the preparation of energy conservation standards by providing technical assistance and advice.

Sec. 5. TECHNICAL ASSISTANCE PROGRAM. The State Building Commission, after consultation with the Governor's Energy Advisory Council and the Texas Department of Community Affairs, shall prepare model energy conservation building codes and make them available for use by cities in enacting or amending their ordinances.

Sec. 6. STAFF. The State Building Commission may employ staff necessary to carry out the provisions of this Act.

Sec. 7. ENERGY CONSERVATION MANUAL. (a) Within 180 days after the effective date of this Act, the State Building Commission shall produce and publish an energy conservation manual for potential use by designers, builders, and contractors of residential and nonresidential buildings. The manual shall be furnished on request at a reasonable price sufficient to cover the costs of printing and help defray research costs in establishing design standards. The manual shall contain the following:

(1) guidelines for energy conservation established by the State Building Commission;

(2) forms, charts, tables, and other data to assist designers and builders in meeting the guidelines;

(3) design suggestions for meeting or exceeding the guidelines; and

(4) any other information which the State Building Commission finds will assist persons to become familiar with the latest technologies that they might use in meeting the guidelines.

(b) The manual shall be updated periodically as significant new energy conservation information becomes available.

Sec. 8. AMENDMENT. Article 1175, Revised Civil Statutes of Texas, 1925, as amended, is amended by adding Subdivision 35 to read as follows:

35. A home-rule city may require all buildings to be constructed in accordance with energy conservation standards

included in the building code, if any.

Sec. 9. EFFECTIVE DATE. This Act takes effect on January 1, 1976.

Sec. 10. EMERGENCY. The importance of this legislation and the crowded condition of the calendars in both houses create an emergency and an imperative public necessity that the constitutional rule requiring bills to be read on three several days in each house be suspended, and this rule is hereby suspended, and that this Act take effect and be in force from and after January 1, 1976, and it is so enacted.

S.B. No. 516

President of the Senate

Speaker of the House

I hereby certify that S.B. No. 516 passed the senate on March 19, 1975, by the following vote: Yeas 30, Nays 1; April 21, 1975, senate concurred in house amendment by a viva-voce vote.

Secretary of the Senate

I hereby certify that S.B. No. 516 passed the house, with amendment, on April 17, 1975, by the following vote: Yeas 129, Nays 0.

Chief Clerk of the House

Approved:

Apr 30, 1975
Date

Governor

1:30 pm O'CLOCK

APR 30 1975

Secretary of State