

NASHVILLE SOLAR-WATER-HEATER
DEMONSTRATION PROJECT

TVA/OP/ECR--82/39(9-11)

DE83 900173

Monitoring-Data Analysis

Interim Report

September 1981 - November 1981

MASTER

March 1982

Technical Support Section
Solar Applications Branch

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EDB

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Summary

This document presents thermal performance data from the Nashville Solar Water Heating Demonstration project for the period September 1, 1981 through November 30, 1981. Because solar water heater performance is strongly related to weather conditions, results from this report cannot be extrapolated to apply for an annual evaluation. In addition, the number of sites presently being monitored does not constitute a representative sample size. Therefore, this report does not draw conclusions or propose solutions. A comprehensive report will address these findings at the completion of this monitoring project when approximately 100 sites will have been monitored.

The table on the next page shows both directly measured and derived performance indicators for each calendar month for the average system.

The next interim monitoring report will analyze data for the period December 1981 through February 1982.

	September	October	November
<u>SAVINGS¹</u>			
Electric Consumption Savings (kWh/month)	188	144	149
Average Savings Percentage (%)	61	38	31
Average Dollar Savings ² (\$)	7.82	6.51	6.73
<u>PEAK kW REDUCTIONS³</u>			
Average Weekday for 12-Hour Period (kW)	0.33	0.32	0.32
Maximum Hourly Reduction in an Average Weekday (kW/time)	0.51/ 8 p.m.	0.56/ 8 a.m.	0.53/ 9 a.m.
<u>SAMPLE CHARACTERISTICS</u>			
Total Number of Sites Analyzed	20	24	26
Average Number of Occupants Per Site	3.7	3.6	3.6
<u>HOT WATER USEAGE - gallons/day</u>			
Average Weekday	70	72	80
Average Weekend-day	75	73	82
Average Day of the Month	71	73	81
Average Day of the Month Per Occupant	19.2	20.3	22.5
<u>MONTHLY ENERGY TRANSFERRED - kWh/month</u>			
Thermal Load Delivered (measured)	247	301	383
Electric Consumption by Solar System (measured)	121	232	329
Electric Consumption of Conventional Electric Water Heater ¹ (calculated)	309	376	478
<u>MAXIMUM MONTHLY SAVINGS (best site)</u>			
Electrical Consumption Savings ¹ (kWh)	346	419	392
Average Day of the Month Hot Water Useage (gal)	85	149	173
Dollar Savings ² (\$)	14.37	18.93	17.71

¹Solar water heaters are compared analytically to a typical well insulated conventional electric water heater (80-percent efficient) that delivered the same thermal load.

²Dollar savings based on electric rates charged by Nashville Electric Service during September (\$0.04157/kWh), and October and November (\$0.04519/kWh). This rate was calculated for RS-10 all over 500 kWh.

³Computed for TVA's system peak periods: weekdays 10:00 a.m. to 10:00 p.m. in September and 6:00 a.m. to 12 noon and 4:00 p.m. to 10:00 p.m. in October and November.

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INTRODUCTION

General

The purpose of this report is to present the three months of field monitoring data that were collected for the Nashville Solar Water Heater Demonstration Project from September through November of 1981. Twenty-six solar domestic water heater systems (SDWHS) were monitored during September, 35 SDWHS were monitored during October, and 37 SDWHS were monitored in November. It is important to realize that the results presented from these three months of data in this report may not be representative of the results of 12 months of data collected from the 100 systems that will be monitored.[1]¹ However, the data collected does show that all of the SDWHS were operating during the period.

Future Reports

Interim reports will be issued quarterly until the monitoring project has been completed when a detailed final report will present all findings.

PROGRAM SUMMARY

Program Overview

The Nashville Solar Water Heater Demonstration Project undertaken in cooperation with the Nashville Electric Service (NES) was approved by the TVA Board as the second stage of TVA's solar water heating program. This area was chosen because a market analysis showed that, next to Memphis, Nashville had the largest number of:

- o Electric water heater installations (129,000)
- o New home starts (3,500 per year)
- o People between the ages of 25 and 49 (259,000)
- o Families earning \$25,000 or more annually (53,000)
- o High school and college graduates (125,000)

National research indicates that all these factors positively influence the market potential for solar systems.

Program Features

Homeowners that have been audited to assure adequate solar access can select a SDWHS from an approved list supplied by the auditor. This list contains the approved manufacturer's name and system model, the estimated annual energy saved by the SDWHS, and the manufacturer's suggested installed price to the consumer (see Table 1 in the Appendix). A credit check of the homeowner is conducted by NES. The homeowner is allowed to select the system and installer of his/her choice. Once the system has been installed, the system is inspected by a TVA or NES quality assurance inspector to ensure compliance with TVA guidelines. Final payment to the installing contractor is made after an installation passes inspection with a 50-percent payment allowed after the first inspection of a substantially completed system that does not comply with TVA's inspection criteria.

¹The number in brackets refers to reference listed at the end of the paper.

SOLAR DOMESTIC WATER HEATER SYSTEM DESCRIPTION

All SDWHS have been generically separated into two-tank and one-tank systems. Typical schematics of these systems are shown in Figure 1 and Figure 2 in the Appendix.

MONITORING SAMPLE TECHNIQUE

The 100 systems to be monitored will be stratified two ways, by system type and family size. Proportional allocation to each of these subdivisions should yield the maximum information from the sites monitored. Initial estimates of the proportion of the sites to be monitored in each of the family size subdivisions (1-2, 3-4, and 5 or more) were obtained from surveys of the electric customers in the Nashville area. These surveys indicate that 45 percent of all households have 1 or 2 family members, 35 percent 3 or 4, and 20 percent 5 or more family members. These surveys included families in multi-family dwellings as well as single family dwellings. Since most solar water heaters will be installed in single family dwellings, the estimates of family size may not accurately reflect the Nashville project. Demographic data will be collected from all monitored and non-monitored SDWHS customers to show the relation between those initially surveyed and those installing SDWHS. As demographic information on the Nashville project is received, the proportion in each family size group will be updated. Table 2, in the Appendix, shows the sales statistics and the proportions in each family size group through November of 1981.

Monthly data on the number of contracts and installations for each of the manufacturer's systems will be used to revise the sampling allocation.

MONITORING SYSTEM DESCRIPTION

Four variables are measured and recorded at 15-minute intervals. These variables are: (1) solar thermal load supplied to the water stream, (2) total thermal load supplied to the water stream by the SDWHS, (3) gallons of hot water used, and (4) total electrical load used for the water heater elements, solar loop pump(s), and differential controller. For one-tank systems, the first variable, thermal energy added to the water stream by solar, cannot be monitored with only one channel. In the future, this unused channel for one-tank systems may be used to measure water main inlet temperature.

Each site has a Robinton load profile recorder (LPR) that stores this information in solid-state memory. Once a day an HP-1000 computer in Knoxville calls each site over a dedicated conventional telephone line. The Robinton answers the call and transfers the stored information to the HP-1000 in coded format. This coded format is then translated to a format compatible with analysis programs.

Additional data are collected from 4 site-read registers which are used for backup data. These registers display: (1) thermal energy added to the water stream by solar, (2) total thermal energy added to the water stream by the SDWHS, (3) gallons of hot water consumed, and (4) solar loop pump(s) run time. There are only three registers for the one-tank system, since thermal energy added to the water stream cannot be monitored with one

channel. NES's meter readers record these data as they read the total electric meter for the house. Each month NES sends TVA the site-read recordings and the total electric meter reading for the entire house. However, those data were not available for the period of this report.

ANALYSIS METHOD

The collected data were analyzed by computer to produce one-page monthly reports that present daily and monthly total summaries for each site. The additional values are also presented on daily and monthly total summary report: (1) Total Hot Water Consumption, (2) Total Electrical Load Used, (3) Total Monthly Thermal Load Supplied by the Solar System, (4) Total Energy Gained From Solar, (5) Total Savings in Dollars, (6) Energy Multiplier, (7) Solar System Savings Percentage, (8) Total Energy Saved by Solar System, (9) Average Daily Energy Saved by Solar System, (10) Average Daily Hot Water Consumption, (11) Average Daily Electrical Load Used, (12) Average Daily Total Thermal Load Supplied by the System, (13) Average Daily Solar Thermal Load Supplied by the Solar, (14) Average Daily Savings in Dollars, and (15) Days of Data. These terms are defined in the Appendix.

The daily and monthly summary report for each site was analyzed to verify the data were valid. The data were then edited to remove or correct any anomalies. If no complete days of data were available, the site was removed from the group average. When the data editing was completed a final report was prepared for each site which included monthly average graphs of the four measured parameters. These individual site reports were not included in this report due to the voluminous material. However, these reports are stored at the Solar Applications Branch. The group average was analyzed for average weekday, average weekend-day, and average day of the month and presented in this report. In addition, the diversified daily profile for all four parameters is also generated.

The performance of each site was assessed by comparing: (1) Total Energy Saved by Solar System, (2) Solar System Savings Percentage, and (3) Energy Multiplier. These terms are defined in the Appendix.

PROGRAM STATUS

As of November 1981, 4,305 requests for audits had been received, 1,132 contracts have been signed, and 864 systems had been installed and passed inspection. A sales summary through November is presented in Table 2 in the Appendix. The manufacturer's name has been replaced by a number. Additional systems were approved for sale during September through November of 1981. These three systems offer higher performance than the average system previously approved. Interestingly, recent sales statistics show consumer awareness by their use of the published system performance list to choose the high performance systems. About sixty-five percent of the sales from September through November were one-tank systems which are the higher performers.

A similar list of the 37 monitored systems presented in this report is shown in Table 3 in the Appendix.

EXPLANATION OF DATA USED

Approximately 100 percent of the possible data were collected in September, October, and November. However, for calculating group averages, 74 percent in September, 62 percent in October, and 74 percent in November, of the data were used. More data of adequate quality were available to use except: (1) when new sites were initialized or as old sites were repaired and reinitialized the first three or four days of data could not be used, and (2) when one channel was not performing satisfactorily, the other channels were not used (sometimes this occurred for only several scans but data for the entire day were not used, other times this happened the entire month). As new sites were initialized, the data collected were used. Since not all new sites were started on the first of the month, and some sites were repaired during the month, the number of days of data collected for the average system could be less than the number of days in that month. Table 20 in the Appendix summarizes reasons the data were not used by site.

Data were collected on Eastern Standard Time for all sites. Central Daylight Savings Time used in Nashville is the same as Eastern Standard Time, the time on which the data were collected. Therefore, no adjustment is required for September and October. On October 18, Nashville local time changed from Central Daylight Savings Time to Central Standard Time. To adjust November data to Nashville local time, one hour must be subtracted from Eastern Standard Time. These adjustments should be kept in mind when interpreting these tables and graphs.

RESULTS

One of the measured variables, the monthly average weekday hot water consumption in gallons per day, increased slightly, with 69.6 in September, 72.4 in October, and 80.4 in November. The monthly average number of people per household was 3.7 in September, 3.7 in October, and 3.6 in November. The September, October, and November average weekday water consumption profiles had two peaks, one in the morning and another in the evening. The morning peak was slightly higher than the evening peak as shown in Figure 3, 8, and 13. The September and October profiles were quite similar except there was a slight time shift when water was used. Whereas, the November profile showed a much larger morning peak than September and October. The profile also showed a significant increase in water usage in the middle of the day between the two peaks. There was also a one-hour time shift when water was used. This was caused by the time change. Interestingly, the monthly average weekend-day water consumption in gallons per day, increased with 74.8 in September, 72.9 in October, and 81.9 in November. The September, October, and November average weekend-day profiles were much more erratic with many peaks between the two normal peaks, one in the morning and one in the evening. The morning peak started about one-two hours later in the morning on the weekend. Also, the average weekend-day's evening peak in September, October, and November was slightly less than the morning peak.

For a second measured variable Q_{AUX} , the total electrical load used, the monthly average weekday value in kWh per day increased from 4.1 in September to 7.6 in October, and to 11.1 in November. The electrical load profile for an average weekday in September had a decreased and flattened morning peak (as shown in Figure 4). Once the September morning peak

decreased, the profile gradually decreased until the next morning's peak started. The average weekday October profile shown in Figure 9 had a low morning peak similar to the September profile. However, there was an evening peak slightly higher than the morning peak. The average weekday November profile showed a larger sharp peak in the morning with a broad peak in the evening (as shown in Figure 14). For an average weekend-day, the electrical load profiles for September, October, and November were similar to the average weekday except the electrical load started one to two hours later in the morning. The November average day morning peak was slightly larger than the average weekday morning peak.

The third measured variable Q_{TOTAL} , the monthly average weekday total thermal load supplied to the water stream in kWh per day, steadily increased from 8.2 in September to 9.7 in October, and to 12.8 in November. The September, October, and November average weekday Q_{TOTAL} profiles shown in Figures 5, 10, and 15 were similar as expected to the average weekday hot water consumption profiles as were seen in Figures 3, 8, and 13. This constant increase in average weekday Q_{TOTAL} was expected because the water main temperature decreased.

The fourth measured variable Q_{SOLAR} , the monthly average weekday solar thermal load supplied to the water stream in kWh per day including the heat losses from the solar tank and heat exchanger inefficiencies, decreased from 7.6 in September to 5.8 in October, and to 5.0 in November. This was due to the lower solar energy available and lower ambient temperatures. The September and October average weekday Q_{SOLAR} profiles had a smaller peak in the morning with a larger peak in the evening as shown in Figure 6 and 11. Whereas in November, the larger peak occurred in the morning (as shown in Figure 16). As stated previously, Q_{SOLAR} was only measured for 2-tank systems. In a 2-tank system the collected solar energy was stored in the solar tank. This stored energy was only transferred to the auxiliary tank when hot water was used. Therefore, the larger peak occurred concurrently with the major hot water usage.

The electrical energy savings to the homeowner in kWh per day, compared to a conventional electric water heater for an average day of the month decreased from 6.3 in September to 4.7 in October, and increased to 5.0 in November. This conventional electric water heater was assumed to be 80-percent efficient and to supply the same thermal load. The Solar Savings Percentage, the percentage savings over this conventional electric water heater over the month, decreased for the average solar system from about 61 percent in September to 38 percent in October, and to 31 percent in November.

An additional analysis was performed to determine TVA's peak demand reduction. First the electrical load (Q_{AUX}) profile for a conventional electric water heater that used the same average weekday water consumption profile as the average solar system was calculated for September, October, and November.

Then the two electrical load profiles for each month were plotted on the same figure as shown in Figures 7, 12, and 17. The difference between the two curves was the amount that the average solar system reduced TVA power requirements. The numerical values for these profiles are presented in Tables 8, 13, and 18. TVA had established on-peak times of 10:00 a.m. to 10:00 p.m. excluding Saturdays, Sundays, and holidays from May-September (summer peak). TVA had established the winter on-peak times of 6:00 a.m.

to 12 noon and 4:00 p.m. to 10:00 p.m. from October-December and January-April excluding Saturdays, Sundays, and holidays. The average solar system reduced TVA's September hourly electrical demand by an average of 0.33 kW over the twelve hour period with a maximum hourly reduction of 0.51 kW at 8:00 p.m. The average solar system reduced TVA's October hourly electrical demand by an average of 0.32 kW during the twelve-hour period with a maximum hourly reduction of 0.56 kW at 8:00 a.m. In November the average solar system reduced TVA's hourly electrical demand by an average of 0.32 kW during the twelve hour period with a maximum hourly reduction of 0.53 kW at 9:00 a.m.

Table 19, in the Appendix, summarizes the daily group average data by month. Eight months (April through November) of data were presented in this table. The number of sites have steadily increased, with 8 in April, 10 in May, 17 in June, 19 in July, 23 in August, 26 in September, 35 in October, and 37 in November. The average monthly daily hot water consumption in gallons per day, has also varied, with 83 in April, 78 in May, 67 in June, 67 in July, 80 in August, 71 in September, 73 in October, and 81 in November. Another variable, the monthly average total thermal load supplied in kWh per day also fluctuated, with 11.0 in April, 10.3 in May, 8.6 in June, 8.1 in July, 9.2 in August, 8.2 in September, 9.7 in October, and 12.8 in November. This reduction in energy required could have been caused by the monthly increase in city water main temperature in degree Fahrenheit, with 66 in April, 69 in May, 73 in June, 78 in July, 79 in August, 76 in September, 66 in October, and 61 in November.[2] & [3] With higher water main temperature, less energy would be required to heat the water to the same temperature.

The total energy saved by the solar system in kWh per day over an 80-percent efficient conventional electric water heater that supplied the same thermal load has remained relatively constant with 7.1 in April, 5.9 in May, 7.0 in June, 6.6 in July, 7.1 in August, 6.3 in September, 4.7 in October, and 5.0 in November. In May the solar insolation available was significantly lower than normal. It must be noted that these savings are reduced by eight systems that appeared to be operating at less than full potential for part of or the entire period. This was caused by such problems as faulty differential controls which would cause the pump to run excessively or not long enough. Six other systems appeared to have questionable results. Six other sites have such low water consumption that they were underutilized. Consequently, the savings presented here were somewhat less than is expected. It is what can be expected in the field unless the homeowner has some minimal monitoring equipment and takes some personal interest in how his system is operating.

The final variable, Solar Savings Percentage for the month, also fluctuated, with 51.3 in April, 45.6 in May, 65.6 in June, 65.4 in July, 61.7 in August, 61.0 in September, 38.1 in October, and 31.2 in November. This is a little lower than was predicted. This has also been decreased by the same problems discussed in the previous paragraph.

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1. TVA Solar Applications Branch, "Nashville Sample Size Determination," Office of Power ARMS Number H03 810522 500, May 21, 1981.
2. TVA Solar Applications Branch, "Nashville Solar Water Heater Demonstration Project Monitoring Data Analysis Interim Report April-May 1981," Office of Power Information Office Approval Number TVA/OP/ECR-82/23, December 1981.
3. TVA Solar Applications Branch, "Nashville Solar Water Heater Demonstration Project Monitoring Data Analysis Interim Report June-August," Office of Power Information Office Approval Number TVA/OP/ECR-82/39, February 1982.

APPENDICES

DEFINITION OF TERMS

Average Daily Electrical Load Used = The amount of electrical energy in kWh used in an average day for operating the electrical heater elements, differential controller, and the solar system circulating pump(s). This is equal to:

$$\frac{\Sigma Q_{AUX}}{\text{Days of Data}}$$

Average Daily Total Thermal Load Supplied = The amount of thermal energy in kWh delivered by the solar system to the water stream in an average day. This is equal to:

$$\frac{\Sigma Q_{TOTAL}}{\text{Days of Data}}$$

Average Daily Solar Thermal Load Supplied = The amount of thermal energy in kWh gained from solar and passed to the water stream in an average day. This includes the standby losses from the solar tank which have already been subtracted. This is equal to:

$$\frac{\Sigma Q_{SOLAR}}{\text{Days of Data}}$$

Average Daily Energy Saved by Solar System = The amount of electrical energy savings in kWh that the solar system would have saved over a conventional electric water heater in an average day. Where 0.8 is the thermal efficiency of a conventional electric water heater. This is equal to:

$$\frac{\frac{\Sigma Q_{TOTAL}}{0.8} - \Sigma Q_{AUX}}{\text{Days of Data}}$$

Average Daily Savings in Dollars = The amount of electrical energy savings in dollars that the solar system would have saved over a conventional electric water heater in an average day. The present rate for Nashville is RS-10, additional kWh per month over 500 kWh was used. This is equal to:

$$\left[\frac{\frac{\Sigma Q_{TOTAL}}{0.8} - \Sigma Q_{AUX}}{\text{Days of Data}} \right] \times \$0.04157$$

Average Daily Hot Water Consumption = The amount of hot water used in an average day. This is equal to:

$$\frac{\Sigma \text{ Gallons}}{\text{Days of Data}}$$

Days of Data = The number of days of data that was used for analysis.

Energy Multiplier = This is a ratio of the total thermal load supplied by the solar system to the electrical load used by the solar system. This is equal to:

$$E.M. = \frac{\Sigma Q_{TOTAL}}{\Sigma Q_{AUX}}$$

Gallons = The number of gallons of hot water used.

Q_{AUX} = The amount of electrical energy in kWh that the solar system used for operating the electrical heater elements, the differential controller, and the solar system circulating pump(s) and controller.

$Q_{AUX, CONV}$ = The amount of electrical energy in kWh that the conventional water heater system used for operating the electrical heater elements to produce the same thermal load as the solar water heating system.

$$Q_{AUX, SOL} = Q_{AUX}$$

Q_{SOLAR} = The amount of thermal energy in kWh gained from the solar portion of the system and passed to the water stream. This includes the standby losses from the solar tank which have already been subtracted.

Q_{TOTAL} = The energy in kWh delivered by the solar system to the water stream.

Solar System Savings Percentage = The percentage of savings realized from the solar system over a conventional electric water heater. This is equal to:

$$SSSP = 1 - \frac{0.8}{EM}$$

Total Electricity Used = The amount of electrical energy in kWh used during the period of analysis for operating the electrical heater elements and the solar system circulating pump(s). This is equal to:

$$\Sigma Q_{AUX}$$

Total Energy Delivered by Solar System = The amount of energy delivered by the solar system to the water stream during the period of analysis. This is equal to:

$$\Sigma Q_{TOTAL}$$

Total Energy Gained from Solar = The amount of energy in kWh gained from solar and passed to the water stream during the period of analysis. This includes the standby losses from the solar tank which have already been subtracted. This is equal to:

$$\Sigma Q_{SOLAR}$$

Total Energy Saved by Solar System = The amount of energy savings in kWh that the solar system would have saved over a conventional electric water during the period of analysis. This is equal to:

$$\frac{\Sigma Q_{TOTAL}}{0.8} - \Sigma Q_{AUX}$$

Total Savings in Dollars = The amount of energy savings in dollars that the solar system would have saved over a conventional electric water heater during the period of analysis. The present rate for Nashville is RS-10, additional kWh per month over 500 kWh was used. This is equal to:

$$\left[\frac{\Sigma Q_{TOTAL}}{0.8} - \Sigma Q_{AUX} \right] \times \$0.04157$$

Total Water Consumption = The amount of hot water used during the period of analysis. This is equal to:

Σ Gallons

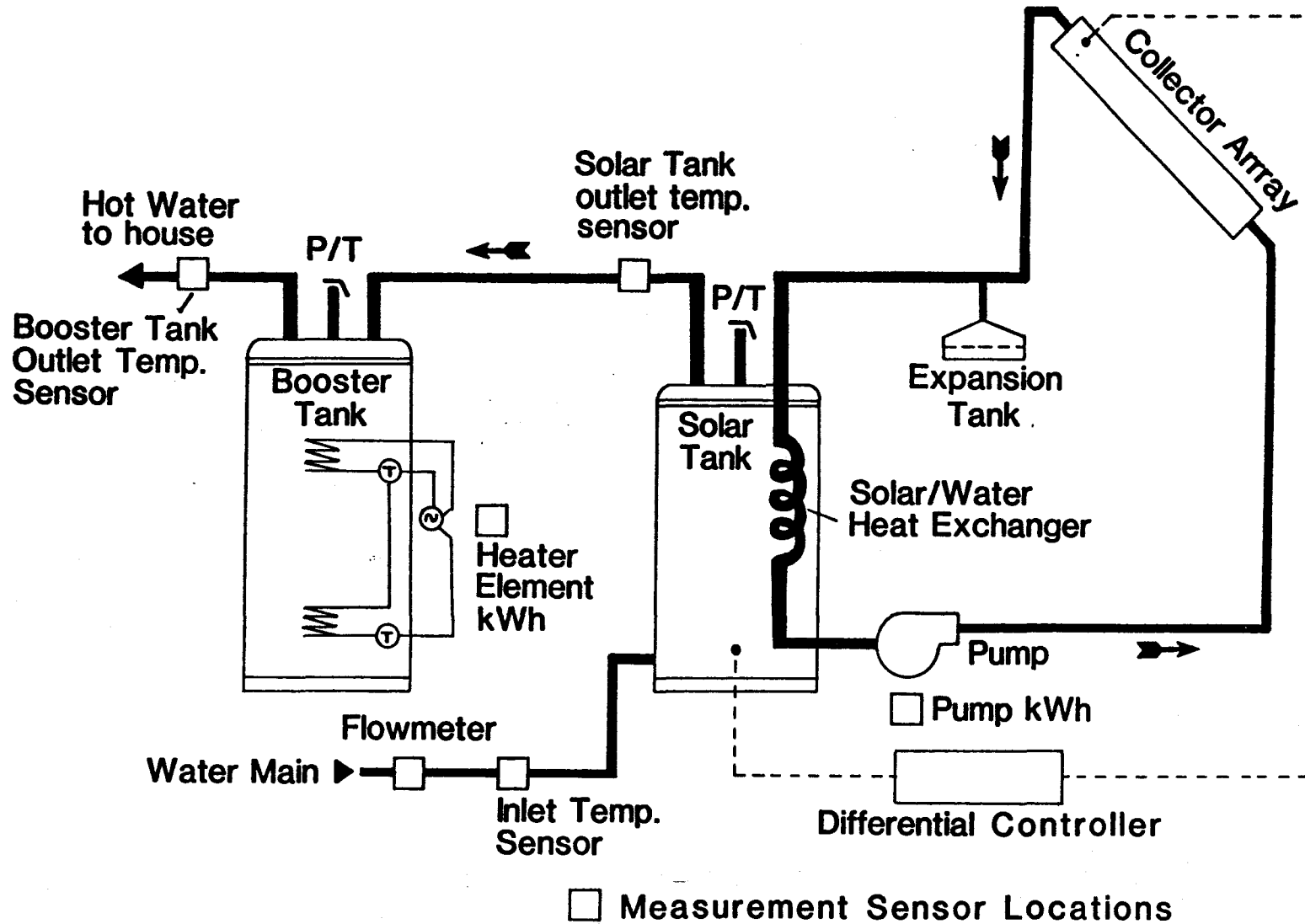


Figure 1. Typical Two Tank System Schematic

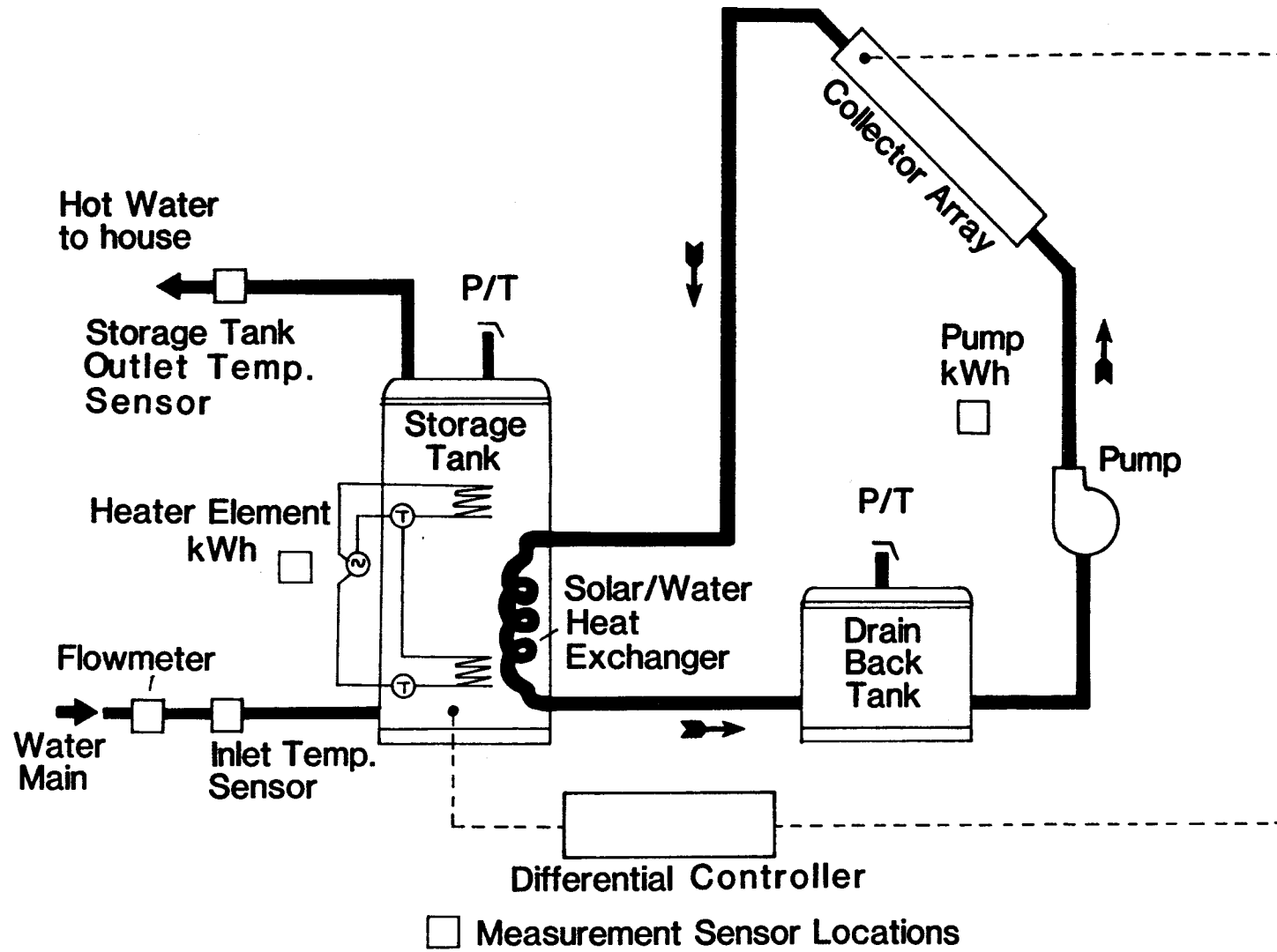


Figure 2. Typical One Tank System Schematic



System

Tennessee
Valley
Authority
Division of
Energy Conservation
& Rates

Performance

ESTIMATED ELECTRICAL USE REDUCTION FOR TVA-LISTED SOLAR WATER HEATING SYSTEMS

System Checked in Laboratory Test	Estimated Annual Kilowatthours of Electrical Energy Saved by System	Manufacturer's Suggested Installed Price to Consumer
Daystar/Solar Energy Master ²	2800	\$3,200.00
Daystar/Solar Energy Master ³	3650	3,500.00
Grumman/(one tank) 332A-NST-82	3300	3,695.00
Grumman/(two tank) 332A-NST-82	3000	3,853.33
InterTechnology Solar Corp/TM-3	3250	3,195.00
Mor-Flo/Collect-A-Ray or Solarstream HWSG 48-120	2100	2,900.00
Mor-Flo/Collect-A-Ray or Solarstream HWSG 72-120	2900	3,200.00
Northrup/DHW 4120	3400	3,325.00
Revere/Sun-Pride NES-003	3750	3,425.00
Reynolds/2-1404-ST	3100	3,310.00
Reynolds/2-1454-ST	3650	3,625.00
Rheem Ruud/(insulated)/SDD82T	3250	3,850.00
Rheem Ruud/(uninsulated)/SDD82T	2800	3,850.00
Solar Industries/12049-2	3600	3,450.00
Solar One/4-16-82-2	2550	2,665.00
Solar One/5-16-82-2	3050	2,975.00
Solar Unlimited/4DP	2900	3,257.00
Sunmaster Corp/Dec-8A/4	3400	3,375.00
Sunworks/Solector Pak 1000/3	3000	3,280.00
U.S. Solar Corp/D-120-80	4350	3,596.00
U.S. Solar Corp/D-120-80-DW	3950	3,836.30

- o The estimated annual kilowatthour equivalent energy saved by the solar water heating system is based on laboratory tests in which hot water is withdrawn from the system at 8 a.m., 12 noon, and 4 p.m. The test load on the system reflects a hot water usage which would require a well-insulated conventional electric water heater, under comparable conditions to consume 5350 kilowatthours annually. Saving to the homeowner varies significantly with the amount of hot water used, when it is used, and with actual weather conditions. Each system performance can be prorated by the factors listed below to provide a more appropriate saving estimate for a particular household. Ask the energy advisor to aid you in this adjustment.

Daily Hot Water Usage (gallons @ 140°F)	Approximate Conventional Electric Water Heater Load (kWh/yr)	Prorate Factor
Low 40	3630	0.76
Test 66	5350	1.00
Typical 80	6190	1.08
High 130	9400	1.28

- o The homeowner should also consider maintenance costs when selecting a solar water heater. Ask the contractor's representative and the energy advisor for this information.
- o The contractor's quoted price may vary due to the requirements that relate to fitting the system to a specific residence, local code requirements, and other factors. Although the consumer and contractor may agree upon a higher or lower price, the maximum that TVA will loan for any system is \$3,400.
- o In order to increase energy saving, it is to the consumer's benefit to keep the electric heating element supply off as much as possible while satisfying hot water needs.

Issued October 22, 1981

TABLE 1. TVA'S LIST OF APPROVED SOLAR DOMESTIC WATER HEATER SYSTEMS (SDWHS)

TABLE 2. SYSTEM DESIGN PARAMETERS AND SALES DATA BY MANUFACTURER
AND FAMILY SIZE THROUGH NOVEMBER 1981

MFG. NO.	COLLECTOR FLUID	HEAT EXCHANGER	NUMBER OF TANKS	COMMENTS	FAMILY SIZE 1-2	% OF TOTAL	FAMILY SIZE 3-4	% OF TOTAL	FAMILY SIZE 5+	% OF TOTAL	TOTAL
2	water	ISW	1	DB	51	5.8	160	18.3	43	4.9	254
5	nonfreezing	EDW	2	--	30	3.4	93	10.6	25	2.9	148
16	nonfreezing	EDW	2	--	17	1.9	54	6.2	14	1.6	85
11	nonfreezing	EDW	2	--	28	3.2	87	9.9	23	2.6	138
18	nonfreezing	EDW	2	--	19	2.2	61	7.0	16	1.8	96
7	water	ISW	2	DB	7	0.8	21	2.4	5	0.6	33
8	nonfreezing	EDW	2	--	4	0.5	12	1.4	3	0.3	19
19	nonfreezing	IDW	2	--	0	0.0	2	0.2	0	0.0	2
12	water	None	2	DDB	7	0.8	21	2.4	6	0.7	34
22	water	ISW	1	DB	13	1.5	40	4.6	11	1.3	63
24	water	None	1	DDD	0	0.0	1	0.1	0	0.0	1
25	water	IDW	1	DB	0	0.0	2	0.2	0	0.0	2
TOTAL					176	20.1	554	63.3	146	16.7	875

Note: All systems use flat-plate collectors except 25 which is an evacuated tube collector.

List of abbreviations: ISW (internal single wall), EDW (external double wall), IDW (internal double wall)
DB (drainback), DDB (direct drainback), DDD (direct draindown)

TABLE 3. ALLOCATION BY MANUFACTURER AND FAMILY SIZE
FOR THE 37 MONITORED SYSTEMS

MFG. NO.	FAMILY SIZE 1-2	% OF TOTAL	FAMILY SIZE 3-4	% OF TOTAL	FAMILY SIZE 5+	% OF TOTAL	TOTAL
2	2	5.4	5	13.5	2	5.4	9
5	4	10.8	6	16.2	3	8.1	13
16	1	2.7	3	8.1	1	2.7	5
18	0	0.0	2	5.4	0	0.0	2
11	1	2.7	2	5.4	3	8.1	6
8	0	0.0	1	2.7	0	0.0	1
12	0	0.0	1	2.7	0	0.0	1
TOTAL	8	21.6	20	54.1	9	24.3	37

NASHVILLE SOLAR WATER HEATER

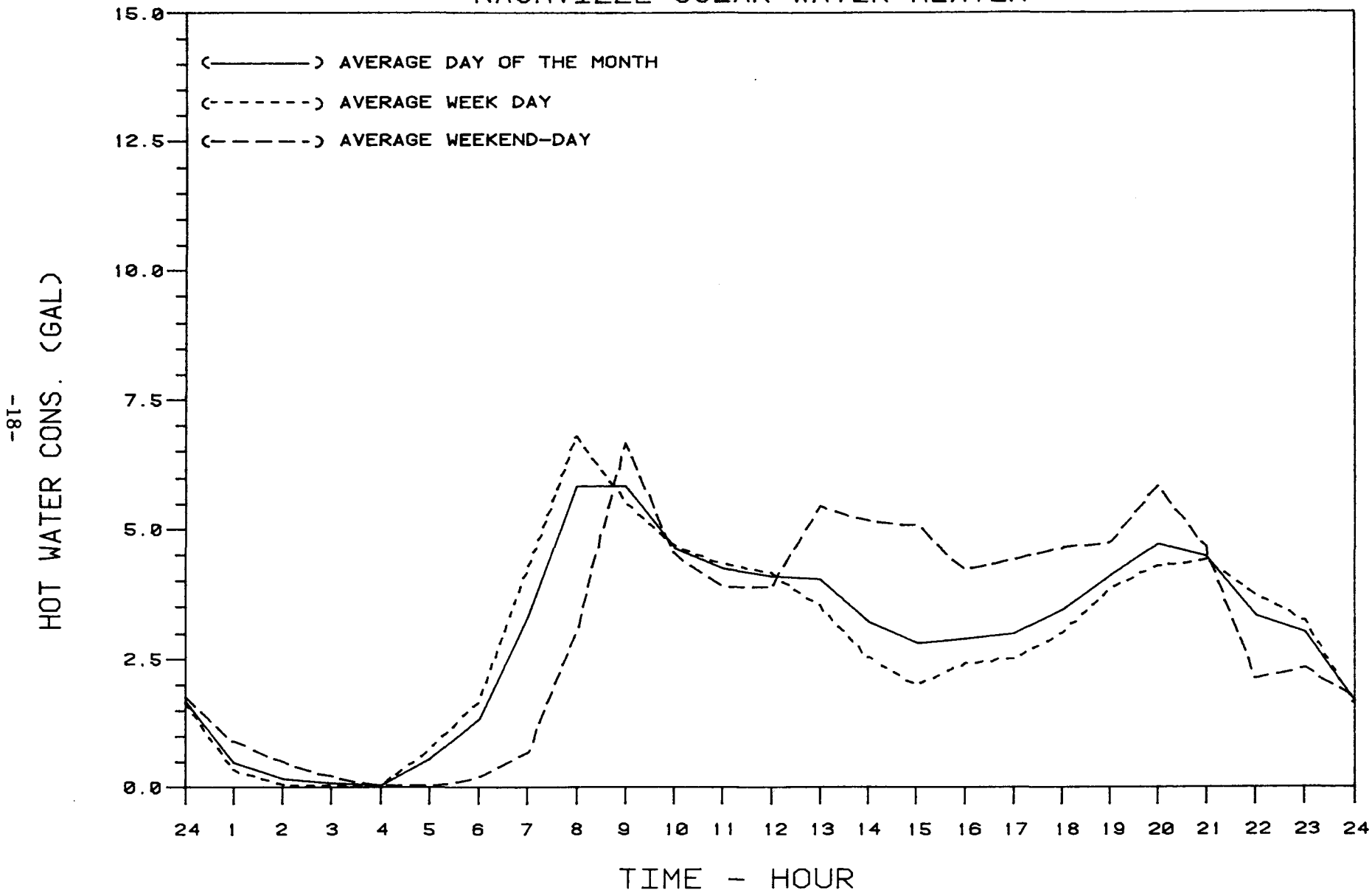


FIGURE 3 PROFILE OF AVERAGE HOT WATER CONSUMPTION FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR SEPTEMBER 1981

NASHVILLE SOLAR WATER HEATER

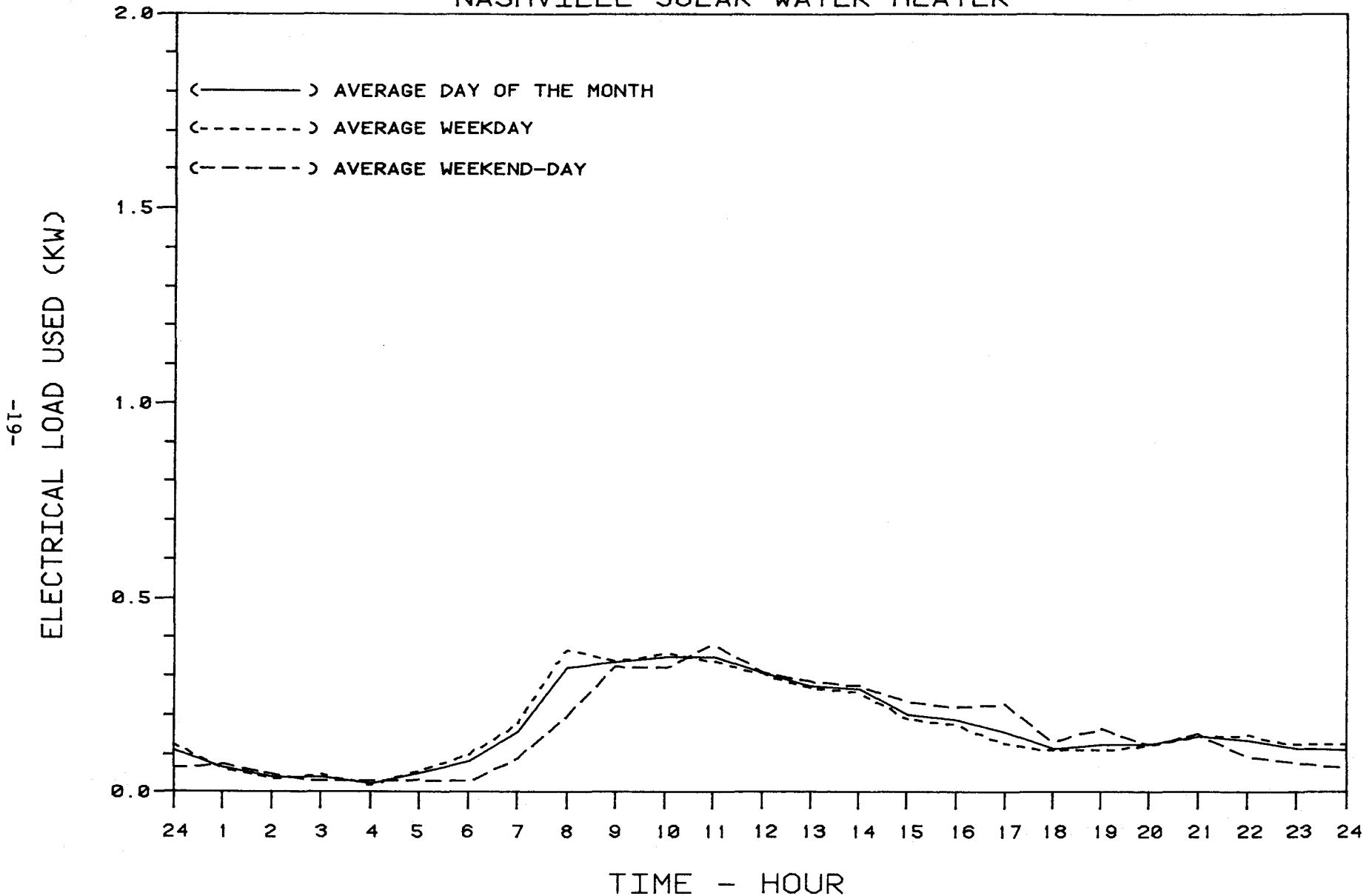


FIGURE 4 PROFILE OF AVERAGE ELECTRICAL LOAD USED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR SEPTEMBER 1981

NASHVILLE SOLAR WATER HEATER

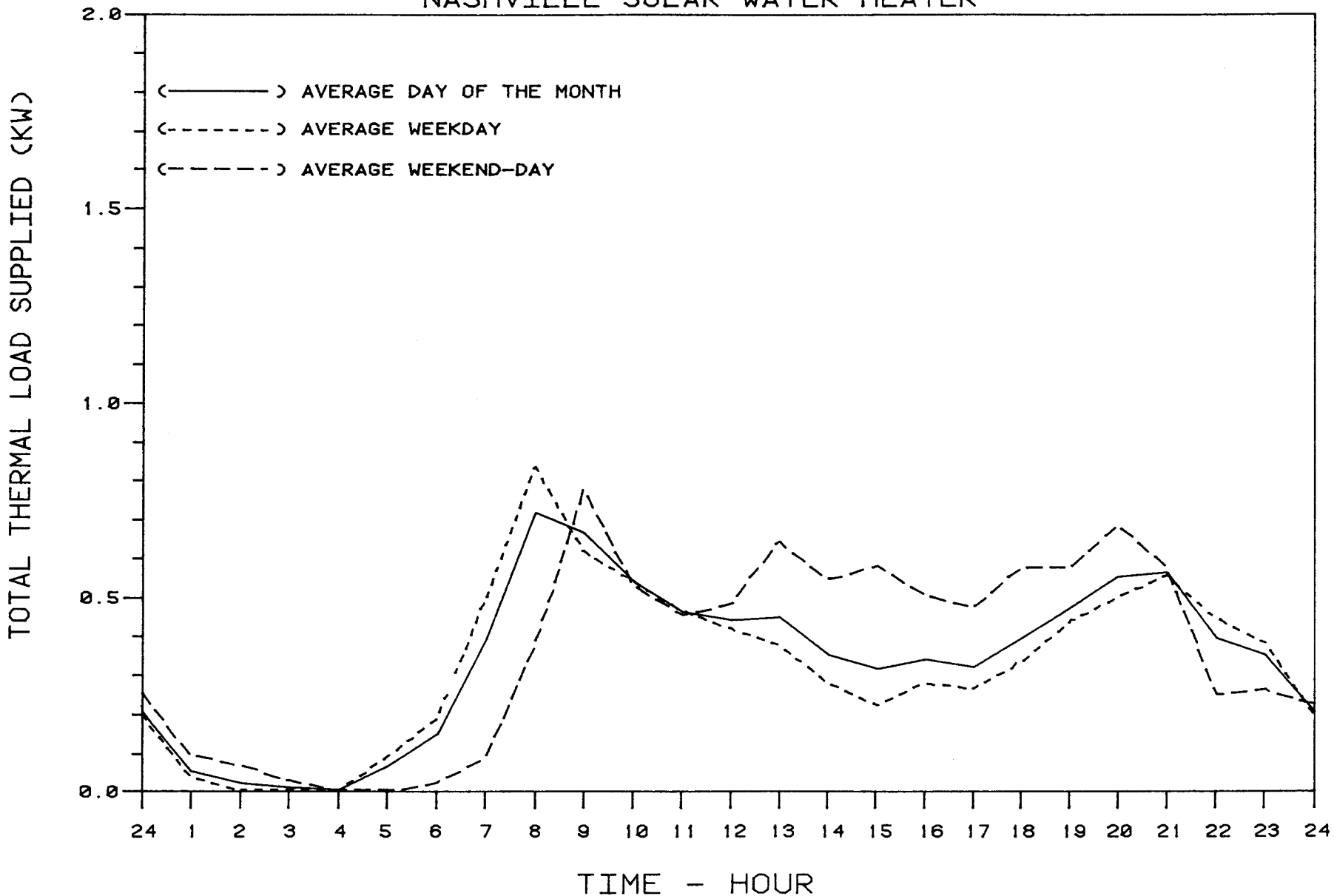


FIGURE 5 PROFILE OF AVERAGE TOTAL THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR SEPTEMBER 1981

NASHVILLE SOLAR WATER HEATER

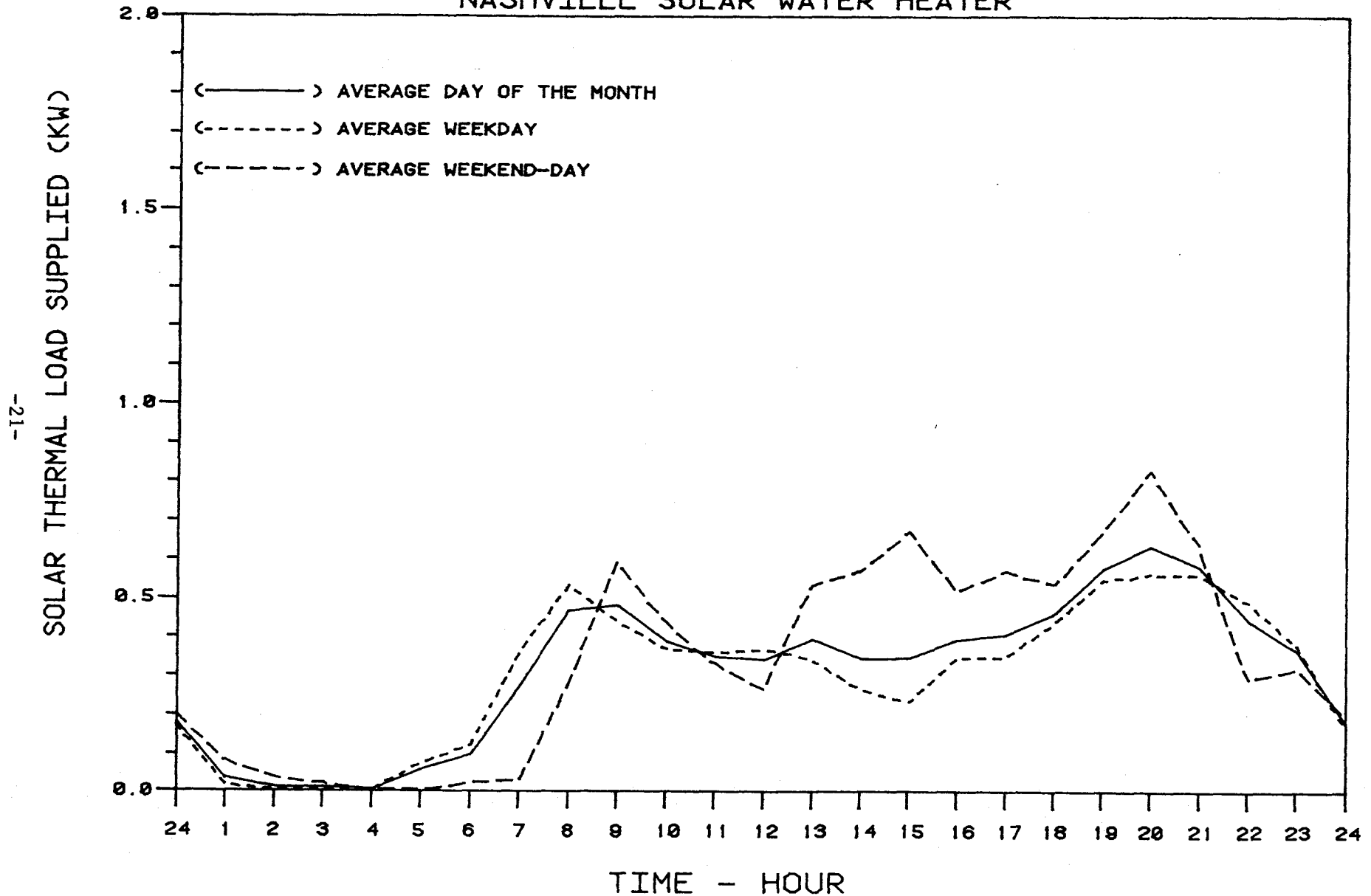


FIGURE 6 PROFILE OF AVERAGE SOLAR THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR SEPTEMBER 1981

TABLE 4 - NUMERICAL VALUES FOR THE PROFILES OF
AN AVERAGE DAY OF THE MONTH
FOR THE MONTH OF SEPTEMBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.034	0.052	0.064	0.477
2:00	0.012	0.022	0.038	0.166
3:00	0.009	0.011	0.040	0.085
4:00	0.004	0.005	0.020	0.039
5:00	0.056	0.067	0.048	0.553
6:00	0.098	0.149	0.079	1.320
7:00	0.274	0.394	0.155	3.307
8:00	0.466	0.716	0.321	5.793
9:00	0.481	0.660	0.334	5.820
10:00	0.387	0.538	0.347	4.630
11:00	0.349	0.464	0.349	4.218
12:00	0.340	0.437	0.306	4.071
13:00	0.392	0.447	0.272	4.015
14:00	0.343	0.350	0.263	3.184
15:00	0.348	0.317	0.200	2.783
16:00	0.394	0.342	0.186	2.870
17:00	0.407	0.319	0.152	2.972
18:00	0.463	0.396	0.110	3.432
19:00	0.578	0.474	0.121	4.089
20:00	0.633	0.550	0.121	4.683
21:00	0.581	0.564	0.144	4.461
22:00	0.439	0.394	0.131	3.309
23:00	0.364	0.351	0.111	2.995
24:00	0.178	0.205	0.107	1.677
TOTAL	7.631	8.226	4.021	70.949

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 70.949 GALLONS
AVERAGE ELECTRICAL LOAD USED = 4.021 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 8.226 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 7.631 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.26
AVERAGE DAILY THERMAL LOAD SAVED = 6.26 KWH

TABLE 5 - NUMERICAL VALUES FOR THE PROFILES OF
AN AVERAGE WEEKDAY
FOR THE MONTH OF SEPTEMBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.019	0.038	0.061	0.332
2:00	0.004	0.005	0.036	0.046
3:00	0.004	0.004	0.044	0.039
4:00	0.004	0.005	0.018	0.040
5:00	0.074	0.089	0.054	0.736
6:00	0.123	0.193	0.097	1.708
7:00	0.360	0.501	0.179	4.234
8:00	0.532	0.836	0.366	6.777
9:00	0.442	0.620	0.338	5.522
10:00	0.370	0.540	0.357	4.670
11:00	0.357	0.467	0.337	4.332
12:00	0.367	0.421	0.305	4.142
13:00	0.343	0.378	0.267	3.518
14:00	0.263	0.281	0.259	2.492
15:00	0.234	0.223	0.189	1.983
16:00	0.349	0.283	0.175	2.402
17:00	0.349	0.265	0.126	2.469
18:00	0.437	0.333	0.103	3.006
19:00	0.545	0.438	0.106	3.852
20:00	0.564	0.502	0.121	4.280
21:00	0.561	0.558	0.143	4.399
22:00	0.491	0.444	0.145	3.728
23:00	0.379	0.382	0.123	3.234
24:00	0.171	0.197	0.123	1.654
TOTAL	7.343	8.003	4.073	69.594

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 69.594 GALLONS
AVERAGE ELECTRICAL LOAD USED = 4.073 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 8.003 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 7.343 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.25
AVERAGE DAILY THERMAL LOAD SAVED = 5.93 KWH

TABLE 6 - NUMERICAL VALUES FOR THE PROFILES OF
 AN AVERAGE WEEKEND-DAY
 FOR THE MONTH OF SEPTEMBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.080	0.094	0.072	0.888
2:00	0.036	0.069	0.044	0.506
3:00	0.022	0.028	0.027	0.215
4:00	0.004	0.005	0.027	0.036
5:00	0.004	0.005	0.031	0.035
6:00	0.024	0.024	0.027	0.221
7:00	0.032	0.092	0.086	0.680
8:00	0.278	0.378	0.194	3.007
9:00	0.592	0.774	0.324	6.662
10:00	0.434	0.531	0.321	4.517
11:00	0.327	0.456	0.383	3.897
12:00	0.266	0.482	0.309	3.870
13:00	0.533	0.644	0.285	5.424
14:00	0.572	0.547	0.275	5.142
15:00	0.671	0.581	0.234	5.052
16:00	0.520	0.509	0.218	4.196
17:00	0.572	0.473	0.226	4.397
18:00	0.534	0.576	0.131	4.641
19:00	0.672	0.577	0.164	4.758
20:00	0.828	0.686	0.121	5.827
21:00	0.638	0.581	0.148	4.636
22:00	0.292	0.252	0.091	2.120
23:00	0.320	0.266	0.078	2.315
24:00	0.198	0.225	0.062	1.743
TOTAL	8.448	8.856	3.877	74.785

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 74.785 GALLONS
 AVERAGE ELECTRICAL LOAD USED = 3.877 KWH
 AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 8.856 KWH
 AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 8.448 KWH
 AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.30
 AVERAGE DAILY THERMAL LOAD SAVED = 7.19 KWH

TABLE 7 - SUMMARY OF DATA BY SITE FOR SEPTEMBER 1981

Site No.	Mfg. No.	Family Size	No. of Days of Data	Q _{SOLAR} (kWh)	Q _{TOTAL} (kWh)	Q _{AUX} (kWh)	Water Consumption (Gal)	Water Consumption (Gal/Day)	Total Energy Saved by System (kWh)	Total Savings (\$)	Solar System Savings Percentage (%)
1	18	4	3	15	13	9	104	35	7	0.29	42.9
2	5	2	23	239	188	21	1,955	85	202	8.40	85.0
3**	5	2	23	87	92	123	876	38	-8	-0.33	-7.0
4	5	2	23	108	88	54	783	34	55	2.29	50.5
5	18	4	23	168	145	51	1,687	73	130	5.40	71.8
6	5	6	23	245	252	78	2,982	130	238	9.89	75.4
7	16	4	23	130	275	152	2,057	89	192	7.98	55.8
8*	16	4	17	70	203	98	2,719	160	156	6.48	61.5
9	2	3	23	N/A	128	20	748	33	140	5.82	87.4
10	5	3	23	225	263	82	2,089	91	246	10.23	74.9
11	5	5	23	224	198	43	3,045	132	205	8.52	82.8
12	11	3	23	216	256	54	1,966	85	265	11.02	85.5
13	2	5	23	N/A	291	362	2,338	102	1	0.04	0.4
14*	16	5	20	212	490	300	3,369	312	168	12.97	51.1
15*	16	4	22	206	317	132	2,780	126	264	10.97	66.8
16	16	2	23	66	51	28	511	22	36	1.50	56.4
17	2	7	9	N/A	138	85	888	99	88	3.66	51.0
18	11	6	13	108	180	115	1,345	103	110	4.57	48.8
19	5	3	23	176	150	32	1,115	48	155	6.44	82.8
20*	8	3	23	279	300	47	3,542	154	327	13.59	87.4
21	not installed										
22	11	4	23	195	271	125	1,936	84	214	8.90	63.2
23	2	2	23	N/A	112	33	792	34	106	4.41	76.1
24	5	3	23	279	197	91	2,322	101	155	6.44	63.0
25	12	4	13	79	78	27	675	52	70	2.91	72.5
26*	5	2	14	0	74	17	0	0	75	3.12	81.4
27*	11	5	3	33	60	26	395	132	49	2.04	65.0

*denotes not included in total or average.

NASHVILLE SOLAR WATER HEATER

COMPARISON OF LOAD PROFILE FOR SOLAR SYSTEM AND CONVENTIONAL WATER HEATER SYSTEM

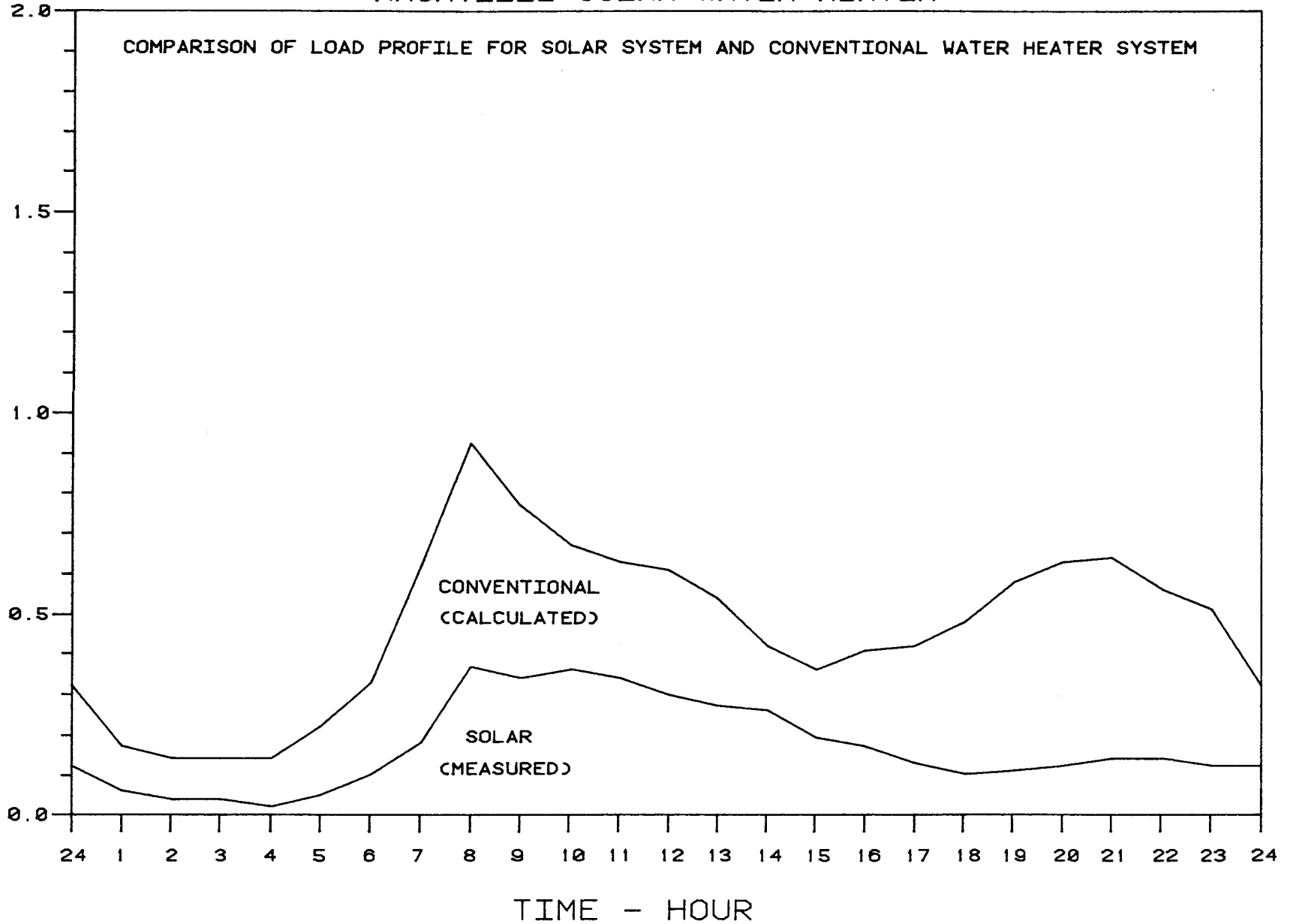


FIGURE 7 AVERAGE WEEKDAY PROFILE OF ELECTRICAL LOAD FOR AVERAGE SOLAR SYSTEM AND CONVENTIONAL WATER HEATER SYSTEM FOR SEPTEMBER 1981

TABLE 8 - NUMERICAL VALUES FOR THE PROFILE OF ELECTRICAL LOAD USED FOR AVERAGE SOLAR SYSTEM (MEASURED) AND CONVENTIONAL WATER HEATER SYSTEM (CALCULATED) FOR AN AVERAGE WEEKDAY SEPTEMBER 1981

TIME OF DAY (HR)	ELECTRIC LOAD USED BY AVERAGE SOLAR SYSTEM (kW)	WATER CONSUMPTION (GAL)	ELECTRICAL LOAD USED BY CONVENTIONAL ELECTRIC WATER HEATER (kW)
1	0.06	0.33	0.17
2	0.04	0.05	0.14
3	0.04	0.04	0.14
4	0.02	0.04	0.14
5	0.05	0.74	0.22
6	0.10	1.71	0.33
7	0.18	4.23	0.62
8	0.37	6.78	0.92
9	0.34	5.52	0.77
10	0.36	4.67	0.67
11*	0.34	4.33	0.63
12*	0.30	4.14	0.61
13*	0.27	3.52	0.54
14*	0.26	2.49	0.42
15*	0.19	1.98	0.36
16*	0.17	2.40	0.41
17*	0.13	2.47	0.42
18*	0.10	3.01	0.48
19*	0.11	3.85	0.58
20*	0.12	4.28	0.63
21*	0.14	4.40	0.64
22*	0.14	3.73	0.56
23	0.12	3.23	0.51
24	0.12	1.65	0.32
Total	4.07	69.59	11.23
On Peak Totals	2.27		6.28

*denotes on peak

NASHVILLE SOLAR WATER HEATER

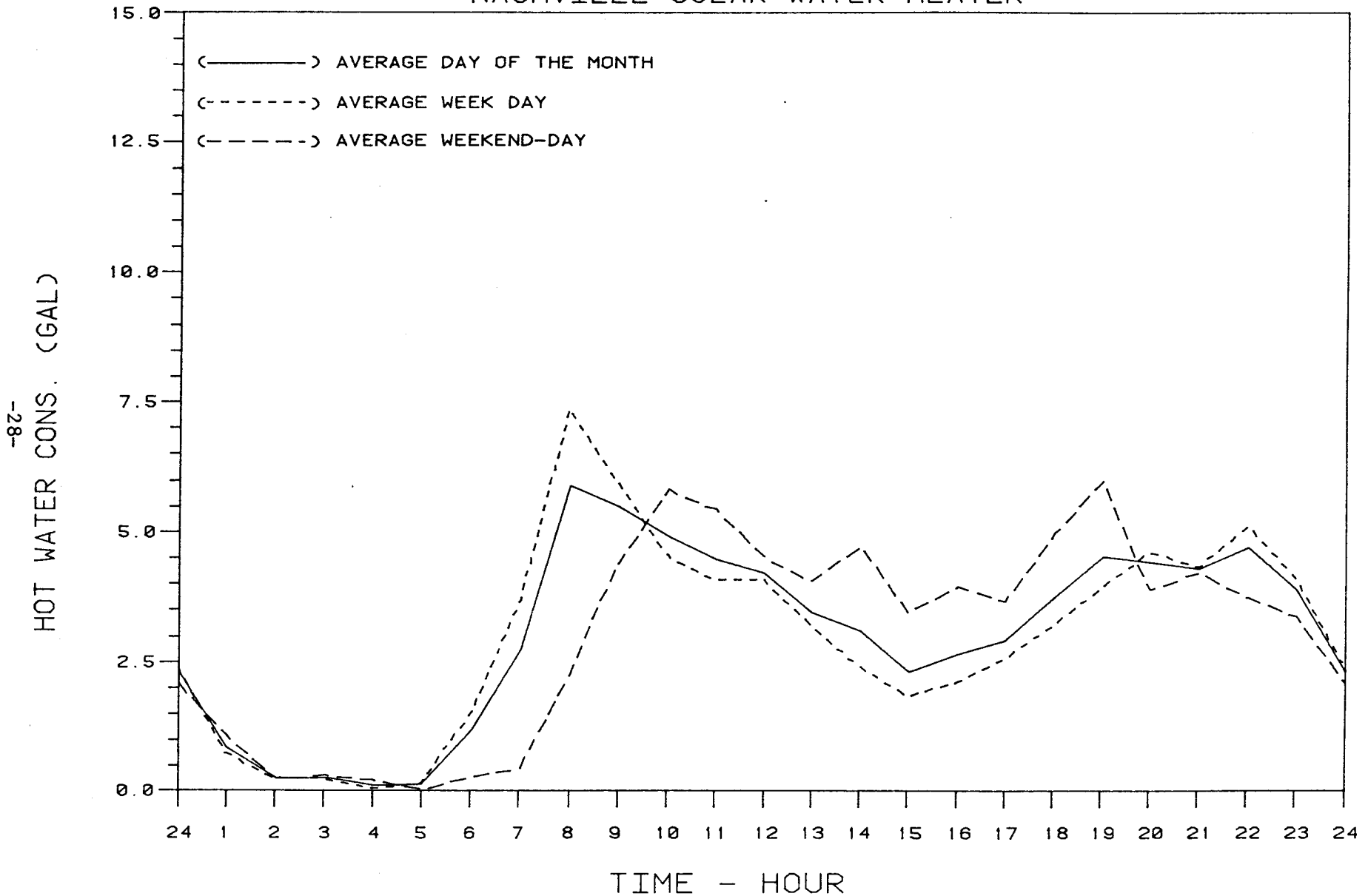


FIGURE 8 PROFILE OF AVERAGE HOT WATER CONSUMPTION FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR OCTOBER 1981

NASHVILLE SOLAR WATER HEATER

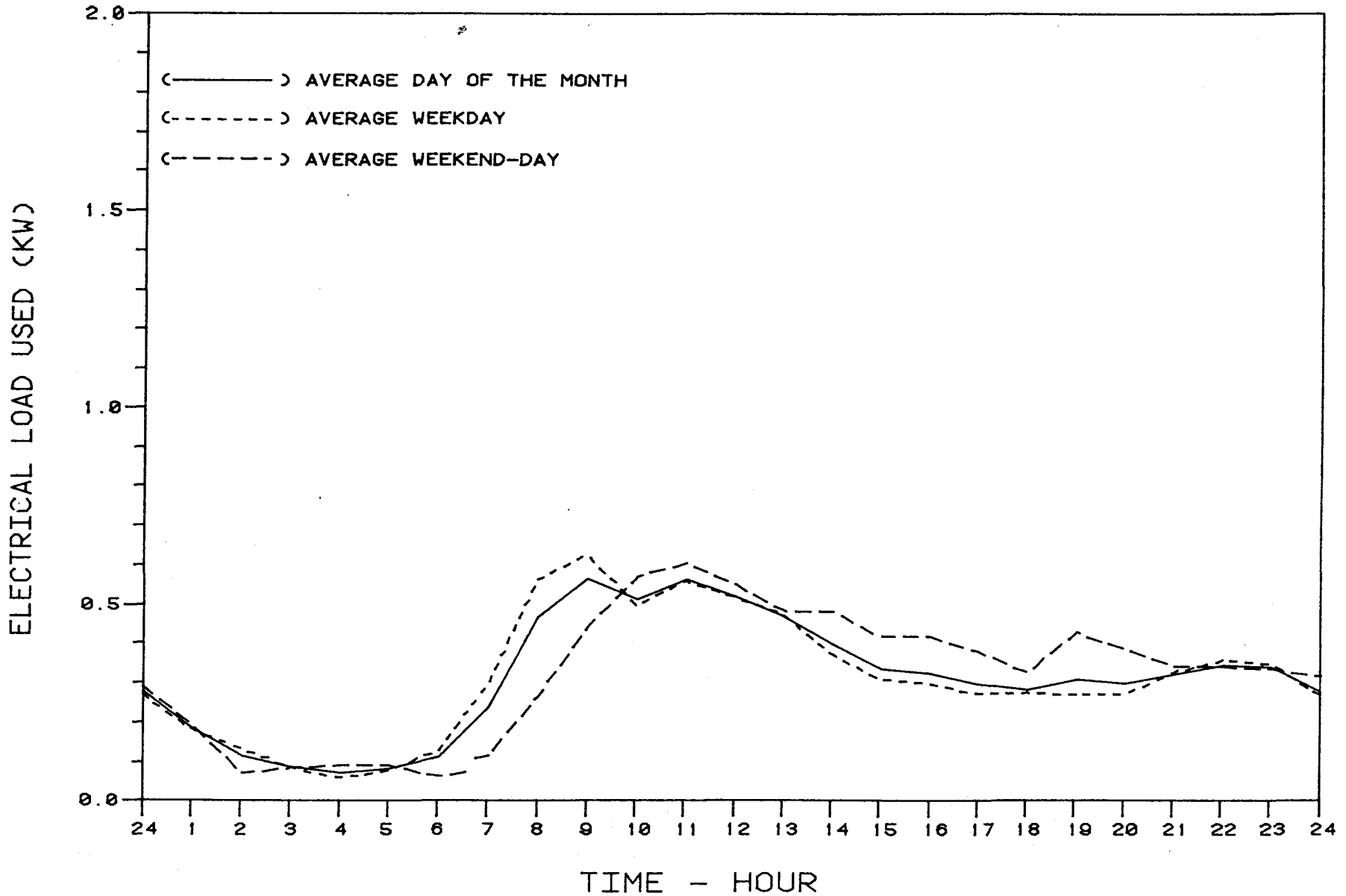


FIGURE 9 PROFILE OF AVERAGE ELECTRICAL LOAD USED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR OCTOBER 1981

NASHVILLE SOLAR WATER HEATER

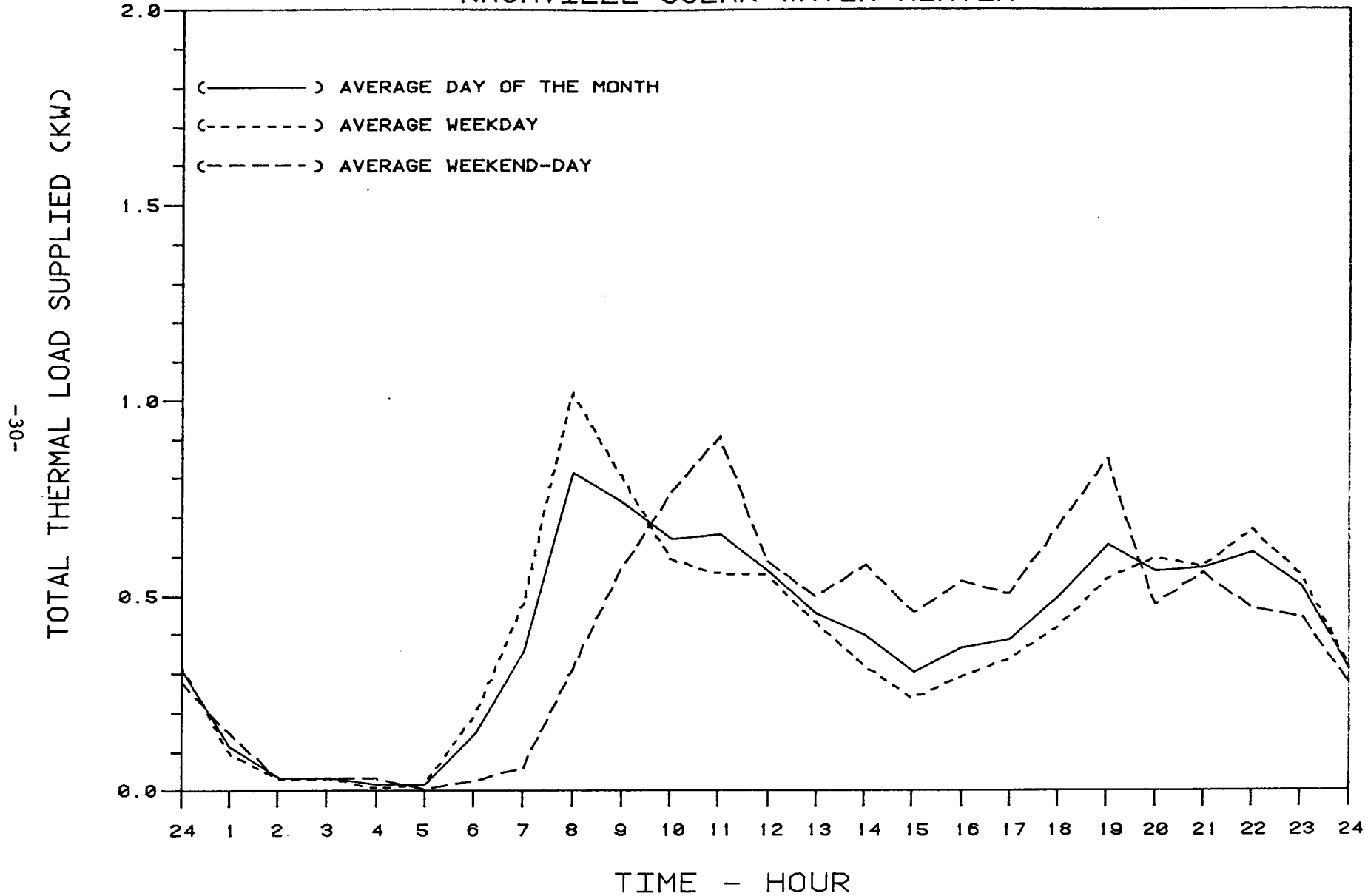


FIGURE 10 PROFILE OF AVERAGE TOTAL THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR OCTOBER 1981

NASHVILLE SOLAR WATER HEATER

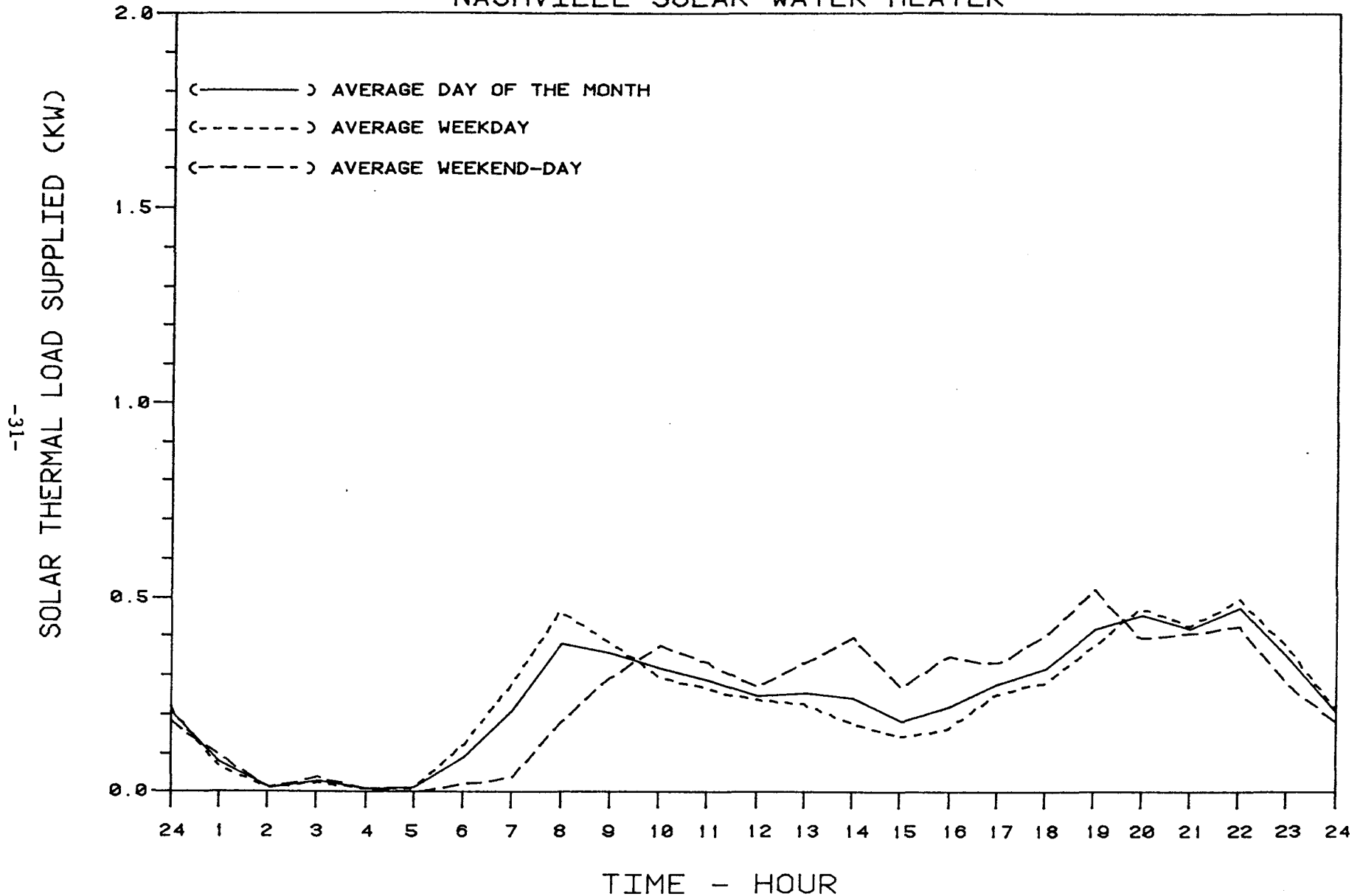


FIGURE 11 PROFILE OF AVERAGE SOLAR THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR OCTOBER 1981

TABLE 9 - NUMERICAL VALUES FOR THE PROFILES OF
AN AVERAGE DAY OF THE MONTH
FOR THE MONTH OF OCTOBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.076	0.111	0.184	0.826
2:00	0.010	0.030	0.112	0.231
3:00	0.028	0.032	0.084	0.258
4:00	0.006	0.014	0.069	0.103
5:00	0.009	0.013	0.081	0.119
6:00	0.092	0.147	0.111	1.187
7:00	0.208	0.359	0.235	2.742
8:00	0.380	0.814	0.467	5.861
9:00	0.356	0.736	0.563	5.469
10:00	0.318	0.642	0.511	4.900
11:00	0.284	0.658	0.565	4.466
12:00	0.246	0.561	0.519	4.208
13:00	0.255	0.452	0.471	3.450
14:00	0.241	0.396	0.395	3.074
15:00	0.180	0.301	0.334	2.307
16:00	0.219	0.364	0.324	2.632
17:00	0.274	0.385	0.295	2.883
18:00	0.317	0.497	0.283	3.725
19:00	0.418	0.631	0.306	4.525
20:00	0.451	0.561	0.294	4.405
21:00	0.418	0.569	0.321	4.281
22:00	0.473	0.610	0.346	4.707
23:00	0.346	0.522	0.336	3.887
24:00	0.205	0.310	0.274	2.285
TOTAL	5.810	9.714	7.482	72.531

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 72.531 GALLONS
AVERAGE ELECTRICAL LOAD USED = 7.482 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 9.714 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 5.810 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.21
AVERAGE DAILY THERMAL LOAD SAVED = 4.66 KWH

TABLE 10 - NUMERICAL VALUES FOR THE PROFILES OF
AN AVERAGE WEEKDAY
FOR THE MONTH OF OCTOBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.067	0.096	0.180	0.722
2:00	0.010	0.029	0.131	0.232
3:00	0.023	0.033	0.084	0.240
4:00	0.006	0.008	0.059	0.063
5:00	0.012	0.017	0.077	0.160
6:00	0.121	0.195	0.130	1.551
7:00	0.278	0.481	0.295	3.685
8:00	0.463	1.020	0.561	7.353
9:00	0.382	0.805	0.625	5.917
10:00	0.294	0.593	0.498	4.538
11:00	0.266	0.555	0.560	4.072
12:00	0.236	0.551	0.518	4.081
13:00	0.225	0.433	0.477	3.203
14:00	0.177	0.321	0.372	2.397
15:00	0.141	0.238	0.311	1.843
16:00	0.165	0.293	0.298	2.103
17:00	0.252	0.336	0.271	2.565
18:00	0.283	0.422	0.276	3.221
19:00	0.376	0.543	0.269	3.935
20:00	0.474	0.595	0.267	4.614
21:00	0.423	0.573	0.322	4.320
22:00	0.493	0.669	0.359	5.108
23:00	0.373	0.553	0.349	4.106
24:00	0.215	0.323	0.269	2.367
TOTAL	5.755	9.684	7.557	72.395

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 72.395 GALLONS
 AVERAGE ELECTRICAL LOAD USED = 7.557 KWH
 AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 9.684 KWH
 AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 5.755 KWH
 AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.21
 AVERAGE DAILY THERMAL LOAD SAVED = 4.55 KWH

TABLE 11 - NUMERICAL VALUES FOR THE PROFILES OF
AN AVERAGE WEEKEND-DAY
FOR THE MONTH OF OCTOBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.096	0.146	0.196	1.079
2:00	0.012	0.031	0.068	0.228
3:00	0.039	0.030	0.085	0.301
4:00	0.006	0.030	0.092	0.202
5:00	0.001	0.002	0.092	0.020
6:00	0.021	0.029	0.064	0.297
7:00	0.037	0.058	0.086	0.437
8:00	0.176	0.308	0.237	2.214
9:00	0.292	0.569	0.413	4.374
10:00	0.376	0.764	0.541	5.784
11:00	0.330	0.909	0.578	5.430
12:00	0.270	0.585	0.523	4.519
13:00	0.331	0.499	0.457	4.054
14:00	0.397	0.577	0.452	4.728
15:00	0.273	0.455	0.390	3.442
16:00	0.349	0.537	0.389	3.927
17:00	0.327	0.505	0.353	3.660
18:00	0.402	0.679	0.300	4.956
19:00	0.519	0.848	0.399	5.966
20:00	0.394	0.478	0.359	3.896
21:00	0.408	0.558	0.317	4.187
22:00	0.425	0.467	0.314	3.726
23:00	0.280	0.445	0.307	3.354
24:00	0.182	0.279	0.288	2.085
TOTAL	5.945	9.789	7.298	72.863

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 72.863 GALLONS
AVERAGE ELECTRICAL LOAD USED = 7.298 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 9.789 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 5.945 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.22
AVERAGE DAILY THERMAL LOAD SAVED = 4.94 KWH

TABLE 12 - SUMMARY OF DATA BY SITE FOR OCTOBER 1981

Site No.	Mfg. No.	Family Size	No. of Days of Data	Q _{SOLAR} (kWh)	Q _{TOTAL} (kWh)	Q _{AUX} (kWh)	Water Consumption (Gal)	Water Consumption (Gal/Day)	Total Energy Saved by System (kWh)	Total Savings (\$)	Solar System Savings Percentage (%)
1	18	4	31	162	223	142	1,824	59	136	6.15	50.0
2	5	2	31	243	240	100	2,505	81	201	9.08	66.9
3	5	2	23	94	134	144	1,139	50	23	1.04	14.0
4	5	2	31	103	120	100	928	30	50	2.26	33.3
5	18	4	31	166	357	379	2,602	84	67	3.03	14.9
6	5	6	31	242	399	256	3,882	125	243	10.98	48.7
7*	16	4	22	71	308	219	2,532	115	167	7.55	43.2
8*	16	4	13	111	253	82	1,072	82	235	10.62	74.2
9	2	3	30	N/A	164	35	1,088	36	169	7.64	82.8
10	5	3	30	210	362	201	2,606	87	252	11.39	55.5
11*	5	5	31	214	419	250	4,806	155	274	12.38	52.3
12	11	3	31	214	417	211	3,259	105	309	13.96	59.4
13	2	5	28	N/A	469	560	3,069	110	27	1.22	4.5
14*	16	5	27	0	894	604	5,227	197	513	23.18	45.9
15	16	4	31	235	629	367	4,630	149	419	18.93	53.3
16	16	2	31	68	78	71	662	21	27	1.22	27.5
17	2	7	10	N/A	116	90	665	66	56	2.52	38.4
18	11	6	31	171	397	328	2,531	82	168	7.59	33.9
19	5	3	31	193	226	108	1,541	50	175	7.90	61.8
20*	8	3	31	275	519	192	5,012	162	457	20.65	70.3
21*	2	4	6	N/A	0	19	0	-	-	-	-
22	11	4	31	182	358	250	2,222	72	197	8.92	44.1
23	2	2	31	N/A	151	61	1,217	39	128	5.78	67.9
24	5	3	31	238	330	318	3,227	104	95	4.29	22.9
25	12	4	19	150	83	97	1,018	54	7	0.32	6.5
26*	5	2	5	0	34	5	0	0	38	1.72	88.6
27*	11	5	31	222	877	614	5,250	169	482	21.78	44.0
28	11	1	11	43	69	53	413	38	33	1.49	38.3
29	2	4	9	N/A	149	129	868	96	58	2.60	30.8

*denotes not included in total or average.

TABLE 12 - SUMMARY OF DATA BY SITE FOR OCTOBER 1981 (contd.)

Site No.	Mfg. No.	Family Size	No. of Days of Data	Q _{SOLAR} (kWh)	Q _{TOTAL} (kWh)	Q _{AUX} (kWh)	Water Consumption (Gal)	Water Consumption (Gal/Day)	Total Energy Saved by System (kWh)	Total Savings (\$)	Solar System Savings Percentage (%)
30	2	4	24	N/A	573	547	3,125	130	170	7.68	22.8
31	5	3	18	70	173	157	1,071	59	59	2.67	27.5
32*	2	2	24	N/A	720	67	6,755	281	833	37.64	92.6
33*	5	4	15	60	70	55	483	32	32	1.45	37.2
34	not installed										
35	not installed										
36*	5	4	9	4	118	93	0	0	54	2.44	37.0
37	11	5	2	21	21	2	217	108	24	1.08	93.0

*denotes not included in total or average.

NASHVILLE SOLAR WATER HEATER

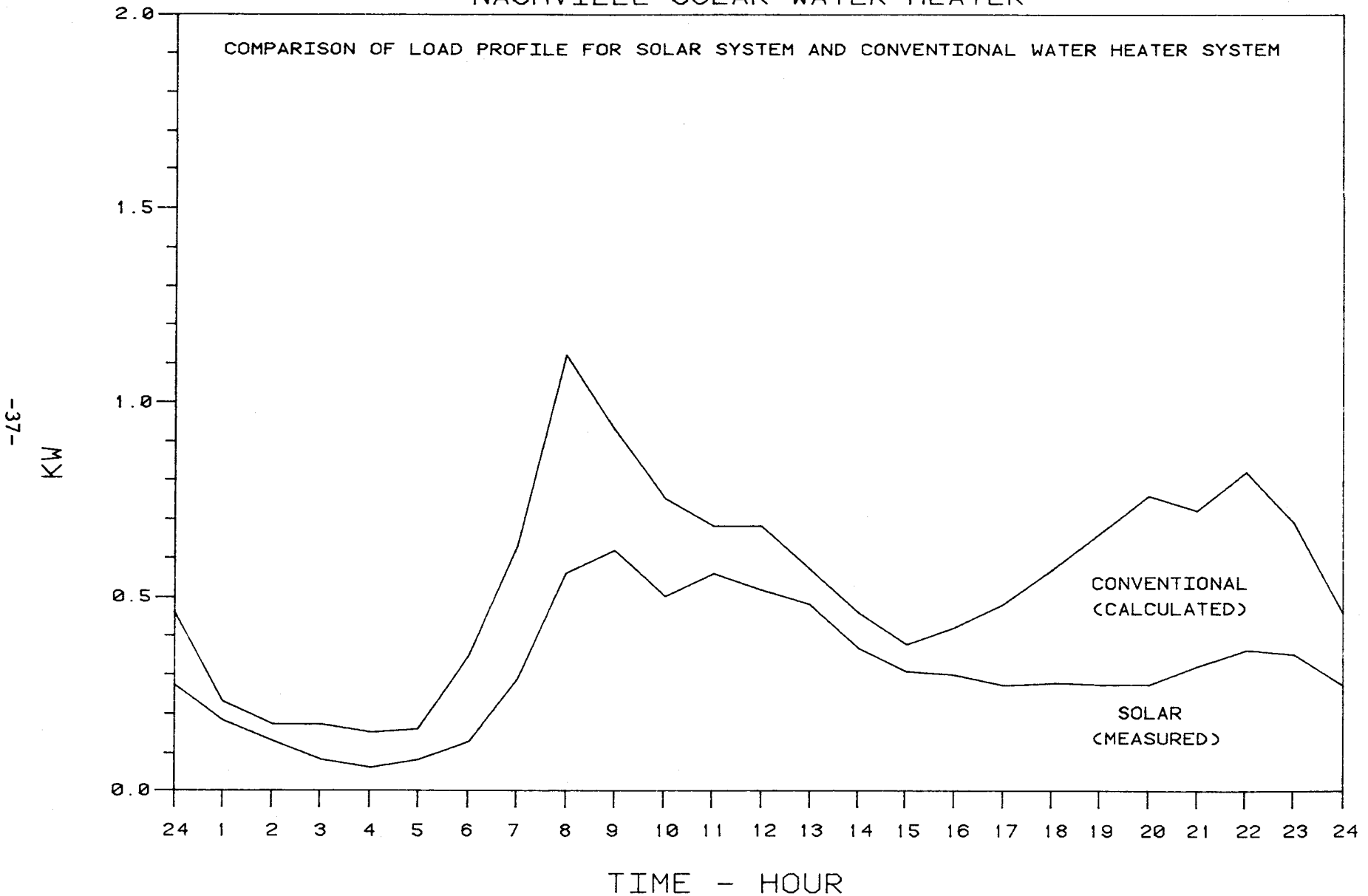


FIGURE 12 AVERAGE WEEKDAY PROFILE OF ELECTRICAL LOAD FOR AVERAGE SOLAR SYSTEM AND CONVENTIONAL WATER HEATER SYSTEM FOR OCTOBER 1981

TABLE 13 - NUMERICAL VALUES FOR THE PROFILE OF ELECTRICAL LOAD USED BY AVERAGE SOLAR SYSTEM (MEASURED) AND CONVENTIONAL WATER HEATER SYSTEM (CALCULATED) FOR AN AVERAGE WEEKDAY OCTOBER 1981

TIME OF DAY (HR)	ELECTRIC LOAD USED BY AVERAGE SOLAR SYSTEM (kW)	WATER CONSUMPTION (GAL)	ELECTRICAL LOAD USED BY CONVENTIONAL ELECTRIC WATER HEATER (kW)
1	0.18	0.72	0.23
2	0.13	0.23	0.17
3	0.08	0.24	0.17
4	0.06	0.06	0.15
5	0.08	0.16	0.16
6	0.13	1.55	0.35
7	0.29	3.68	0.63
8*	0.56	7.35	1.12
9*	0.62	5.92	0.93
10*	0.50	4.54	0.75
11*	0.56	4.07	0.68
12*	0.52	4.08	0.68
13*	0.48	3.20	0.57
14	0.37	2.40	0.46
15	0.31	1.84	0.38
16	0.30	2.10	0.42
17	0.27	2.56	0.48
18*	0.28	3.22	0.57
19*	0.27	3.93	0.66
20*	0.27	4.61	0.76
21*	0.32	4.32	0.72
22*	0.36	5.11	0.82
23*	0.35	4.11	0.69
24	0.27	2.37	0.46
Total	7.56	72.37	13.01
On Peak Totals	5.09		8.95

*denotes on peak

NASHVILLE SOLAR WATER HEATER

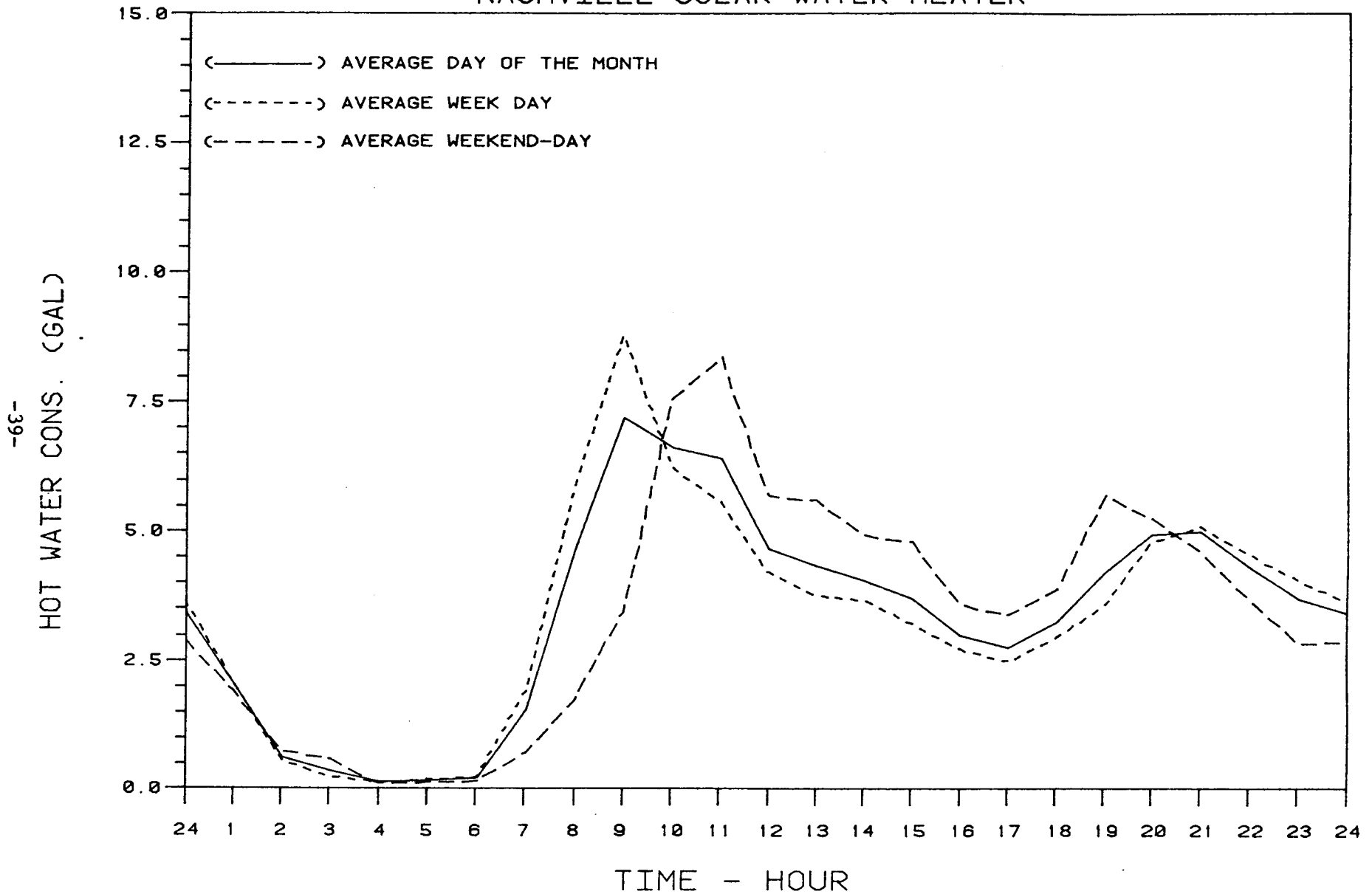


FIGURE 13 PROFILE OF AVERAGE HOT WATER CONSUMPTION FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR NOVEMBER 1981

NASHVILLE SOLAR WATER HEATER

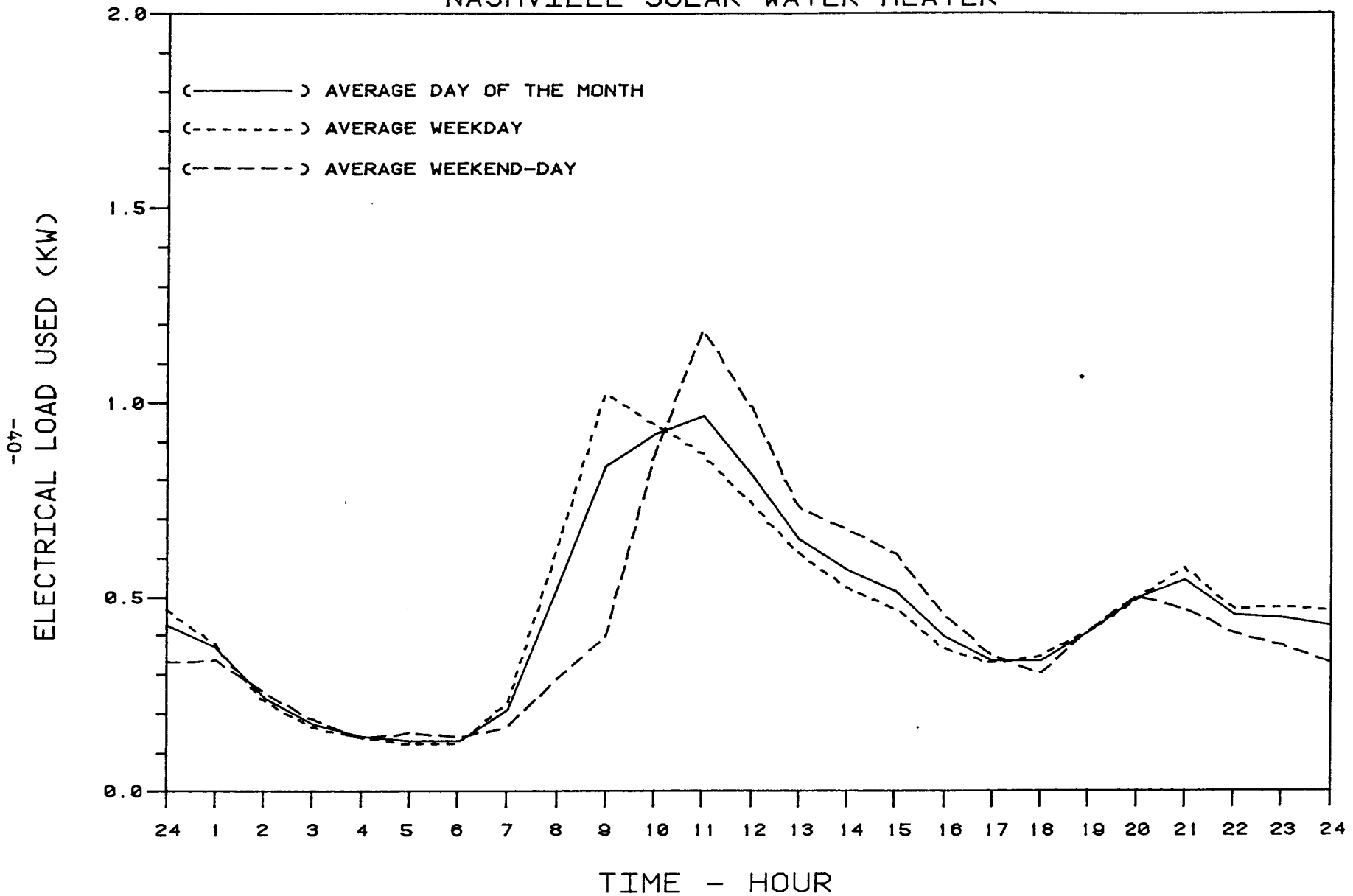


FIGURE 14 PROFILE OF AVERAGE ELECTRICAL LOAD USED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR NOVEMBER 1981

NASHVILLE SOLAR WATER HEATER

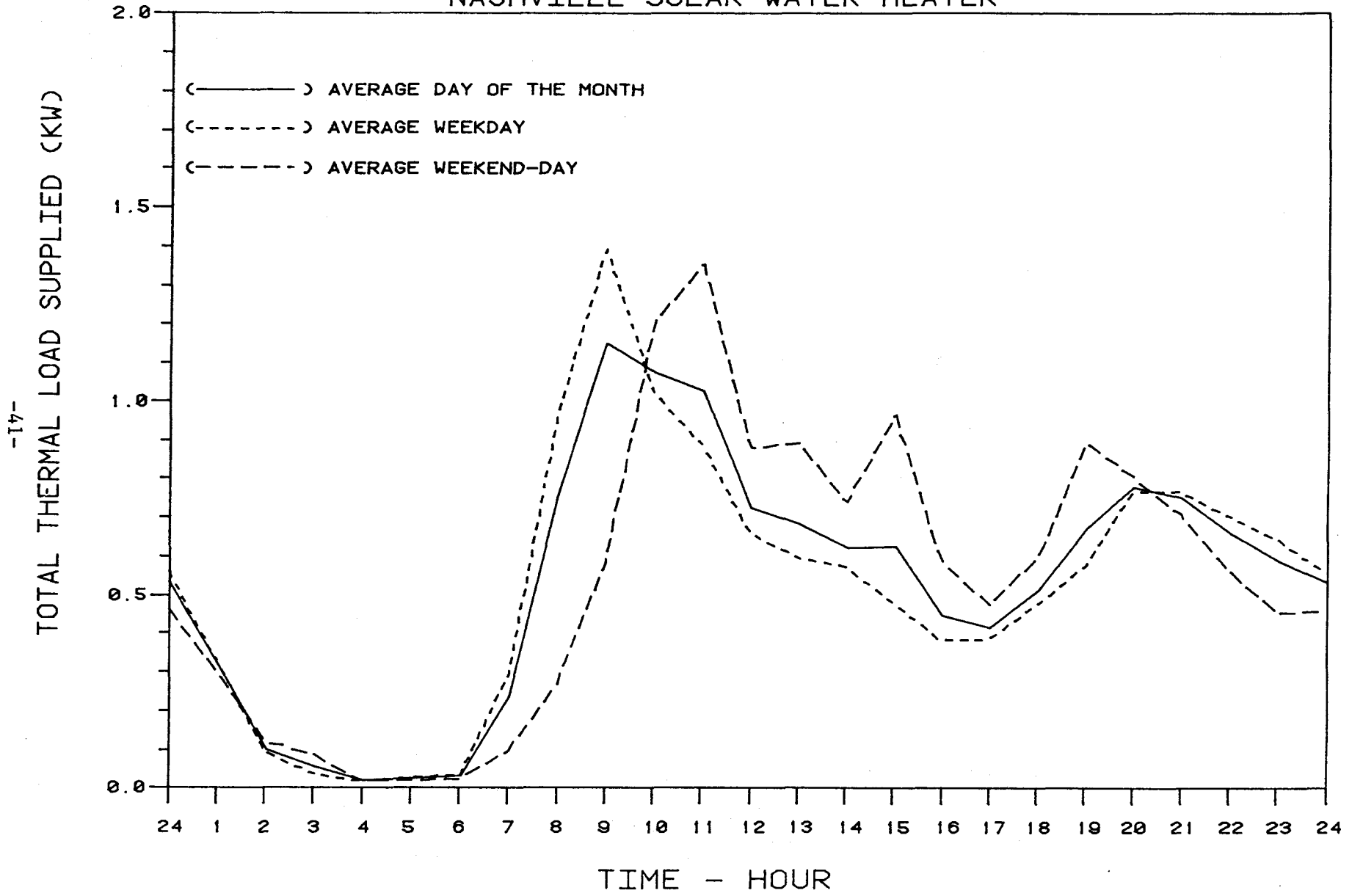


FIGURE 15 PROFILE OF AVERAGE TOTAL THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR NOVEMBER 1981

NASHVILLE SOLAR WATER HEATER

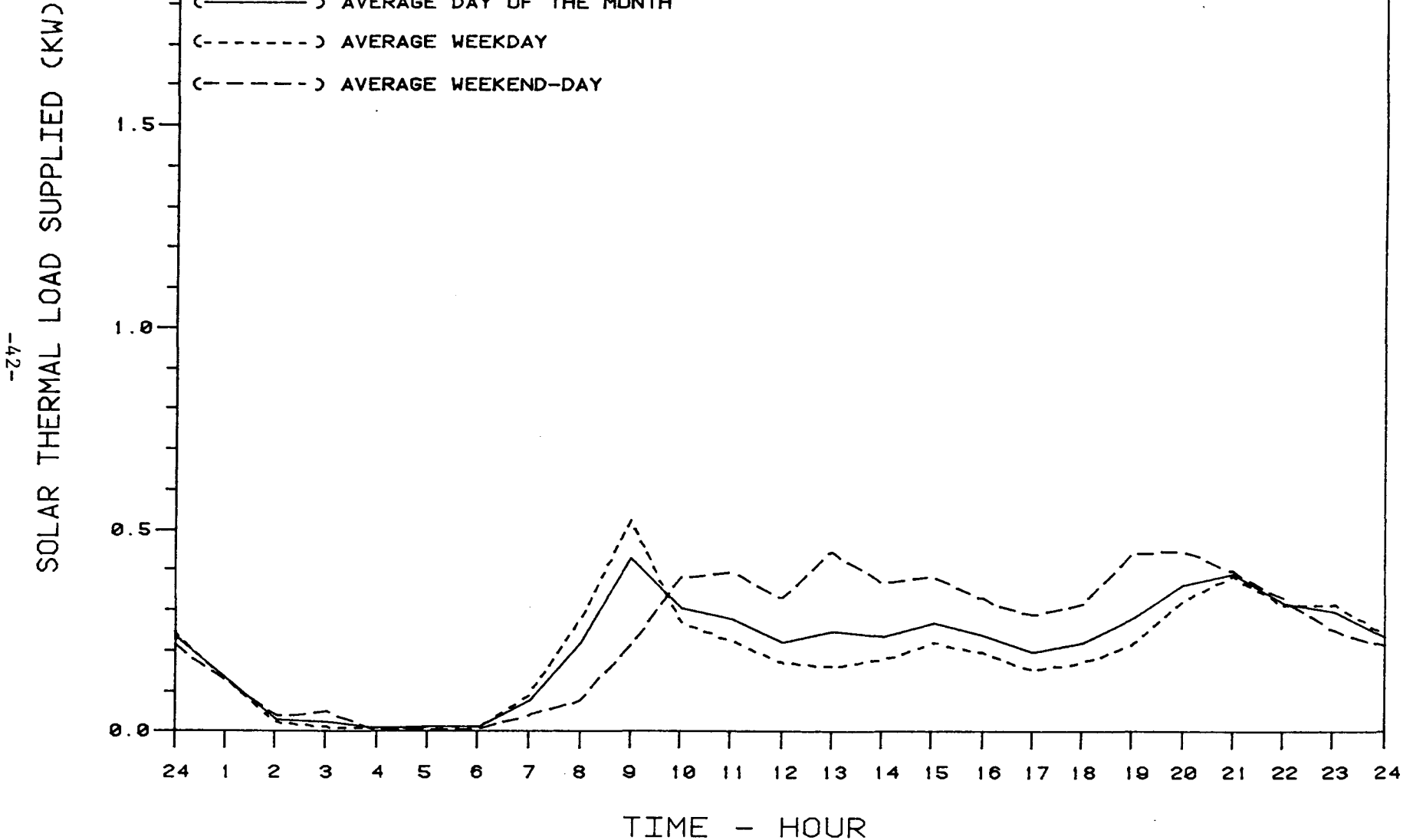


FIGURE 16 PROFILE OF AVERAGE SOLAR THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR NOVEMBER 1981

TABLE 14 - NUMERICAL VALUES FOR THE PROFILES OF
AN AVERAGE DAY OF THE MONTH
FOR THE MONTH OF NOVEMBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.131	0.323	0.367	2.026
2:00	0.028	0.097	0.237	0.607
3:00	0.022	0.051	0.170	0.339
4:00	0.006	0.019	0.138	0.120
5:00	0.009	0.024	0.129	0.161
6:00	0.010	0.032	0.130	0.210
7:00	0.077	0.235	0.208	1.535
8:00	0.214	0.753	0.517	4.608
9:00	0.429	1.147	0.835	7.177
10:00	0.303	1.073	0.919	6.605
11:00	0.275	1.023	0.962	6.388
12:00	0.217	0.722	0.815	4.638
13:00	0.246	0.683	0.647	4.308
14:00	0.234	0.620	0.566	4.027
15:00	0.269	0.623	0.510	3.676
16:00	0.235	0.445	0.395	2.976
17:00	0.194	0.413	0.333	2.739
18:00	0.215	0.512	0.334	3.228
19:00	0.283	0.672	0.411	4.205
20:00	0.360	0.777	0.493	4.942
21:00	0.390	0.748	0.542	4.947
22:00	0.317	0.656	0.451	4.282
23:00	0.295	0.583	0.446	3.681
24:00	0.234	0.527	0.425	3.393
TOTAL	4.995	12.756	10.981	80.818

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 80.818 GALLONS
AVERAGE ELECTRICAL LOAD USED = 10.981 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 12.756 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 4.995 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.22
AVERAGE DAILY THERMAL LOAD SAVED = 4.96 KWH

TABLE 15 - NUMERICAL VALUES FOR THE PROFILES OF
 AN AVERAGE WEEKDAY
 FOR THE MONTH OF NOVEMBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.132	0.332	0.380	2.081
2:00	0.022	0.089	0.229	0.553
3:00	0.012	0.036	0.164	0.236
4:00	0.007	0.019	0.140	0.128
5:00	0.012	0.027	0.121	0.176
6:00	0.011	0.034	0.126	0.234
7:00	0.092	0.294	0.225	1.895
8:00	0.274	0.961	0.615	5.850
9:00	0.521	1.390	1.023	8.784
10:00	0.268	1.015	0.941	6.196
11:00	0.222	0.882	0.867	5.553
12:00	0.169	0.656	0.740	4.203
13:00	0.160	0.594	0.611	3.761
14:00	0.176	0.569	0.521	3.656
15:00	0.220	0.477	0.468	3.209
16:00	0.196	0.384	0.369	2.719
17:00	0.153	0.386	0.326	2.467
18:00	0.171	0.476	0.348	2.959
19:00	0.216	0.577	0.410	3.565
20:00	0.323	0.765	0.490	4.810
21:00	0.387	0.766	0.573	5.093
22:00	0.314	0.700	0.471	4.552
23:00	0.315	0.639	0.476	4.049
24:00	0.244	0.555	0.466	3.621
TOTAL	4.615	12.623	11.100	80.351

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 80.351 GALLONS
 AVERAGE ELECTRICAL LOAD USED = 11.100 KWH
 AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 12.623 KWH
 AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 4.615 KWH
 AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.21
 AVERAGE DAILY THERMAL LOAD SAVED = 4.68 KWH

TABLE 16 - NUMERICAL VALUES FOR THE PROFILES OF
AN AVERAGE WEEKEND-DAY
FOR THE MONTH OF NOVEMBER 1981

***** NASHVILLE SOLAR WATER HEATER PROJECT *****

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	HOT WATER CONSUMPTION (GAL)
1:00	0.130	0.302	0.337	1.898
2:00	0.040	0.118	0.254	0.732
3:00	0.048	0.085	0.185	0.579
4:00	0.004	0.017	0.134	0.102
5:00	0.004	0.019	0.148	0.126
6:00	0.006	0.025	0.139	0.151
7:00	0.041	0.098	0.167	0.696
8:00	0.075	0.269	0.289	1.711
9:00	0.213	0.580	0.397	3.428
10:00	0.384	1.208	0.868	7.560
11:00	0.398	1.352	1.186	8.335
12:00	0.329	0.876	0.988	5.654
13:00	0.446	0.890	0.730	5.586
14:00	0.370	0.738	0.670	4.892
15:00	0.385	0.962	0.609	4.764
16:00	0.327	0.585	0.455	3.576
17:00	0.290	0.474	0.352	3.374
18:00	0.318	0.597	0.302	3.855
19:00	0.442	0.893	0.413	5.698
20:00	0.449	0.804	0.500	5.252
21:00	0.397	0.705	0.468	4.605
22:00	0.327	0.555	0.406	3.652
23:00	0.250	0.452	0.374	2.821
24:00	0.211	0.460	0.330	2.862
TOTAL	5.882	13.065	10.701	81.907

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 81.907 GALLONS
AVERAGE ELECTRICAL LOAD USED = 10.701 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 13.065 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 5.882 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS = \$ 0.25
AVERAGE DAILY THERMAL LOAD SAVED = 5.63 KWH

TABLE 17 - SUMMARY OF DATA BY SITE FOR NOVEMBER 1981

Site No.	Mfg. No.	Family Size	No. of Days of Data	Q _{SOLAR} (kWh)	Q _{TOTAL} (kWh)	Q _{AUX} (kWh)	Water Consumption (Gal)	Water Consumption (Gal/Day)	Total Energy Saved by System (kWh)	Total Savings (\$)	Solar System Savings Percentage (%)
1	18	4	30	161	315	226	2,313	77	168	7.59	42.6
2	5	2	25	172	181	101	1,858	74	126	5.69	55.6
3	5	2	30	122	273	302	1,995	66	39	1.76	11.4
4	5	2	30	105	165	145	1,093	36	61	2.76	29.5
5	18	4	30	159	460	511	2,910	97	64	2.89	11.1
6	5	6	30	204	431	353	3,786	126	185	8.36	34.4
7*	16	4	30	3	471	383	2,721	91	207	9.35	35.1
8	16	4	29	46	238	238	1,113	38	60	2.71	20.1
9**	2	3	30	N/A	286	353	1,567	52	4	0.18	1.1
10	5	3	30	159	325	214	2,409	80	192	8.68	47.4
11*	5	5	30	175	358	198	3,990	133	249	11.25	55.8
12	11	3	30	187	494	306	3,116	104	311	14.05	50.4
13*	2	5	30	N/A	597	701	3,482	129	46	2.08	6.2
14*	16	5	30	0	1,205	921	6,828	221	583	26.35	30.8
15	16	4	30	168	569	396	3,667	122	316	14.28	44.4
16	1	2	30	56	77	85	595	20	11	0.50	11.0
17	2	7	30	N/A	490	415	2,778	93	198	8.95	32.3
18	11	6	30	135	419	391	2,443	81	133	6.01	25.3
19	5	3	30	160	231	141	1,496	50	148	6.69	51.2
20*	8	3	30	213	634	334	5,109	170	458	20.70	57.8
21*	2	4	30	N/A	0	442	0	0	-	-	-
22	11	4	30	165	446	361	2,510	84	197	8.90	35.3
23	2	2	23	N/A	126	82	803	35	75	3.39	47.6
24*	5	3	19	177	217	184	1,945	102	87	3.93	32.1
25*	12	4	30	13	127	166	1,374	46	-8	-0.34	-4.8
26	5	2	13	59	74	41	592	46	51	2.30	55.0
27	11	5	30	170	977	829	5,199	173	392	17.71	32.1
28	11	1	30	175	180	195	1,045	35	30	1.36	13.4
29	2	4	30	N/A	453	395	2,585	86	172	7.77	30.3

*denotes not included in total or average.

**denotes differential controller malfunction.

TABLE 17 - SUMMARY OF DATA BY SITE FOR NOVEMBER 1981 (contd.)

Site No.	Mfg. No.	Family Size	No. of Days of Data	Q _{SOLAR} (kWh)	Q _{TOTAL} (kWh)	Q _{AUX} (kWh)	Water Consumption (Gal)	Water Consumption (Gal/Day)	Total Energy Saved by System (kWh)	Total Savings (\$)	Solar System Savings Percentage (%)
30**	2	4	29	N/A	825	944	4,477	154	86	3.90	8.4
31	5	3	28	104	320	307	1,835	66	93	4.20	23.2
32*	2	2	30	N/A	893	111	7,352	245	-	-	-
33*	5	4	30	74	88	100	584	19	10	0.45	9.4
34	not installed										
35	not installed										
36	5	4	19	100	264	230	1,391	73	100	4.52	30.3
37	11	5	30	194	361	186	3,313	110	265	11.98	58.7
38	not installed										
39	5	5	14	50	215	204	1,274	91	64	2.89	23.8
40*	2	4	19	N/A	1,187	399	1,968	104	-	-	-

*denotes not included in total or average.

NASHVILLE SOLAR WATER HEATER

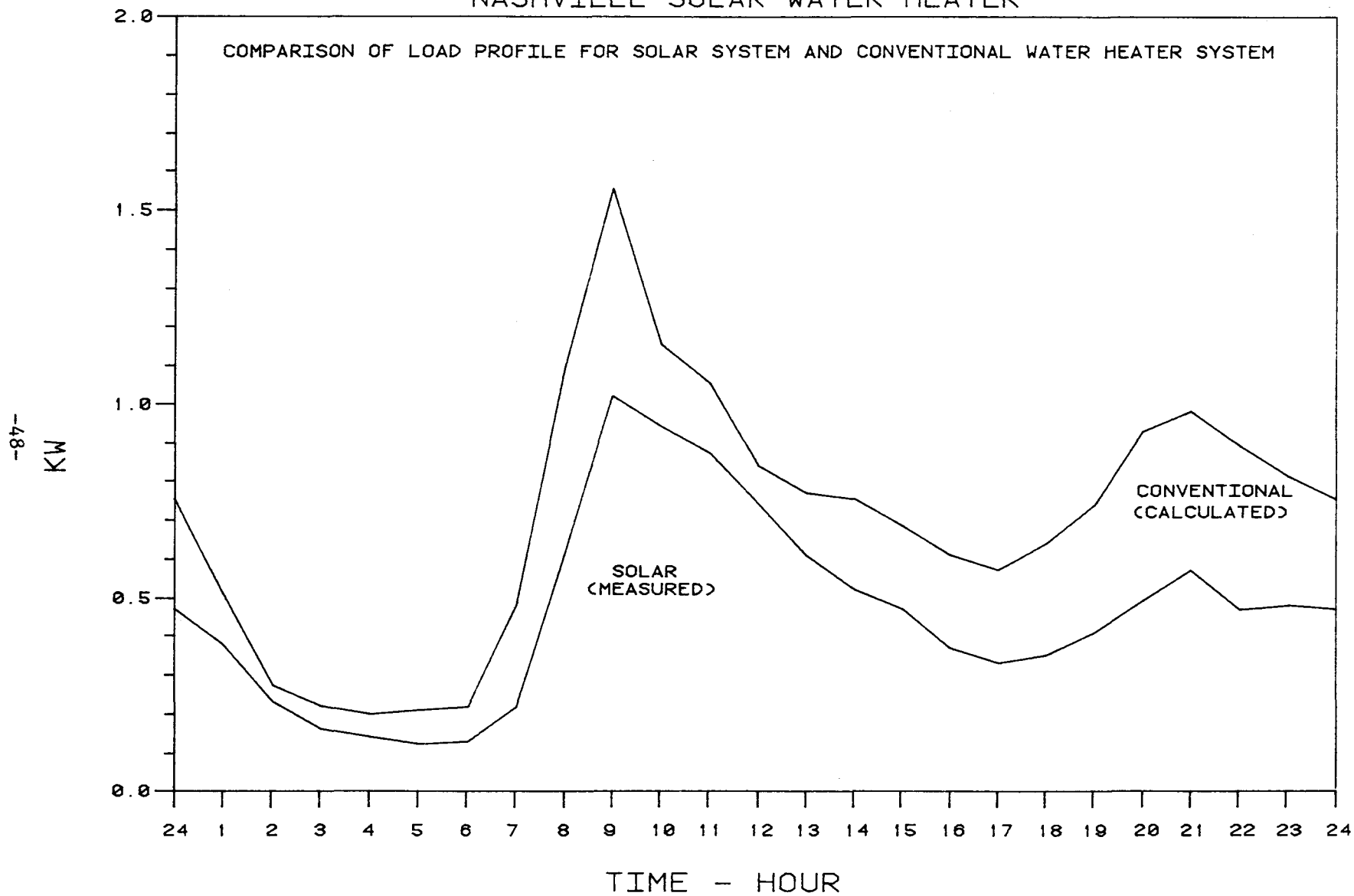


FIGURE 17 AVERAGE WEEKDAY PROFILE OF ELECTRICAL LOAD FOR AVERAGE SOLAR SYSTEM AND CONVENTIONAL WATER HEATER SYSTEM FOR NOVEMBER 1981

TABLE 18 - NUMERICAL VALUES FOR THE PROFILE OF ELECTRICAL LOAD USED FOR AVERAGE SOLAR SYSTEM (MEASURED) AND CONVENTIONAL WATER HEATER SYSTEM (CALCULATED) FOR AN AVERAGE WEEKDAY NOVEMBER 1981

TIME OF DAY (HR)	ELECTRIC LOAD USED BY AVERAGE SOLAR SYSTEM (kW)	WATER CONSUMPTION (GAL)	ELECTRICAL LOAD USED BY CONVENTIONAL ELECTRIC WATER HEATER (kW)
1	0.38	2.08	0.51
2	0.23	0.55	0.27
3	0.16	0.24	0.22
4	0.14	0.13	0.20
5	0.12	0.18	0.21
6	0.13	0.23	0.22
7	0.22	1.89	0.48
8*	0.61	5.85	1.09
9*	1.02	8.78	1.55
10*	0.94	6.20	1.15
11*	0.87	5.55	1.05
12*	0.74	4.20	0.84
13*	0.61	3.76	0.77
14	0.52	3.66	0.75
15	0.47	3.21	0.68
16	0.37	2.72	0.61
17	0.33	2.47	0.57
18*	0.35	2.96	0.64
19*	0.41	3.56	0.74
20*	0.49	4.81	0.93
21*	0.57	5.09	0.98
22*	0.47	4.55	0.89
23*	0.48	4.04	0.81
24	0.47	3.62	0.75
Total	11.10	80.33	16.91
On Peak Totals	7.56		11.44

*denotes on peak

TABLE 19. MONTHLY SUMMARY OF DAILY GROUP AVERAGE - AVERAGE DAY OF THE MONTH

Month	Number Sites	Family Size	Q _{SOLAR} (kWh/day)	Q _{TOTAL} (kWh/day)	Q _{AUX} (kWh/day)	Water Consumption (Gal/day)	Total Energy Saved By System (kWh/day)	Total Savings (\$/day)	Solar System Savings Percent (%)
April[2]	8	3.6	7.2	11.0	6.7	83	7.1	0.30	51.3
May[2]	10	3.7	6.3	10.3	7.0	78	5.9	0.25	45.6
June[3]	17	3.8	7.2	8.6	3.7	67	7.0	0.29	65.6
July[3]	19	3.8	6.5	8.1	3.5	67	6.6	0.28	65.4
August[3]	23	3.7	7.3	9.2	4.4	80	7.1	0.29	61.7
September	26	3.7	7.6	8.2	4.0	71	6.3	0.26	61.0
October	35	3.7	5.8	9.7	7.5	73	4.7	0.21	38.1
November	37	3.6	5.0	12.8	11.0	81	5.0	0.22	31.2

TABLE 20. REASONS WHY SOME DATA WERE NOT USED

SITE NUMBER	DURATION OF OCCURANCE	CAUSE
1	9/12-9/24	Phone line not answering.
2	11/12&11/13	Many hours of too high kWh values.
	11/14-11/16	No date or time.
	11/18&11/19	Many hours of too high kWh values.
5	10/24-11/1	QSOLAR, QTOTAL, Gal reading zeros.
7	10/12	Many hours of too high QSOLAR values.
	10/23-11/31	QSOLAR reading zeros.
	(Oct., Nov.)	Unsatisfactory energy balance.
8	9/2,9/5,9/6	Many hours of too high QTOTAL values.
	9/14&9/16	Many hours of too high kWh values.
	9/28	Many hours of too high Gal values.
	10/2	Many hours of too high QSOLAR and AUX values.
	10/5	Many hours of too high kWh values.
	10/17	Many hours of too high QSOLAR and kWh values.
	11/7	Many hours of too high QTOTAL and kWh values.
	(Sept., Oct.)	Unsatisfactory energy balance.
9	10/27	Many hours of too high kWh values.
10	10/12	Many hours of too high QSOLAR values.
11	11/15	Many hours of too high kWh values.
	(Oct., Nov.)	Unsatisfactory energy balance.
13	10/29-10/31	Many hours of too high kWh and Gal values.
	11/29-11/30	Many hours of too high kWh values.
	(Nov.)	Unsatisfactory energy balance.
14	9/28-11/30	QSOLAR reading zeros and too high water useage.

TABLE 20. REASONS WHY SOME DATA WERE NOT USED (contd.)

SITE NUMBER	DURATION OF OCCURANCE	CAUSE
15	9/1	Many hours of too high Q_{TOTAL}
17	9/11-10/21	Phone stopped answering.
18	9/-9/10	Q_{SOLAR} recording zeros.
20	(Sept., Oct., Nov.)	Unsatisfactory energy balance.
21	10/27-11/30	Q_{TOTAL} and Gal recording zeros.
23	11/4, 11/10, 11/23 & 11/24, 11/27, 11/29, & 11/30	Many hours of too high kWh values.
25	9/11	Initial startup, first full day of data.
	10/21-11/5	Q_{SOLAR} recording zeros.
26	9/12-11/12	Initial startup, first full day of data. Q_{SOLAR} recording zeros.
	11/24	Q_{TOTAL} reading zeros.
27	9/25	Initial startup, first full day of data.
	(Sept. & Oct.)	Unsatisfactory energy balance.
	11/23-11/30	Q_{SOLAR} reading zeros or too low.
28	10/21	Initial startup, first full day of data.
29	10/22	Initial startup, first full day of data.
30	10/8	Initial startup, first full day of data.
31	10/9	Initial startup, first full day of data.
	10/12-10/16	Phone line not answering.
32	10/8	Initial startup, first full day of data.
	(Oct. & Nov.)	Too high water useage.
33	10/17	Initial startup, first full day of data.
	(Oct. & Nov.)	Too low water useage.

TABLE 20. REASONS WHY SOME DATA WERE NOT USED (contd.)

SITE NUMBER	DURATION OF OCCURANCE	CAUSE
36	10/23	Initial startup, first full day of data.
	10/23-11/13	Gal recording zeros.
37	10/30	Initial startup, first full day of data.
39	11/17	Initial startup, first full day of data.
40	11/14	Initial startup, first full day of data.
	(Nov.)	Q _{TOTAL} is too high for water useage.