Solar Nashville Program

Monitoring Data Analysis
Interim Report
June 1981-August 1981

TVA/OP/ECR--82/39

DE83 900171

NASHVILLE SOLAR-WATER-HEATER DEMONSTRATION PROJECT

Monitoring Data Analysis

Interim Report

June 1981 - August 1981

January 1981

Technical Support Section
Solar Applications Branch

Summary

The performances of the 23 monitored solar domestic water heater systems (SDWHS) in the Nashville program were monitored during June through August of 1981. Instrumentation recorded data at 15-minute intervals and transmitted these data every day over conventional telephone lines to be translated and stored on computer tape for later analysis. The quantities measured and recorded were (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 electrical elements, solar loop pump(s), and differential controller. These data were analyzed by computer to produce monthly reports, which included daily and total summaries for each customer.

Approximately 98 percent in June, 99 percent in July, and 96 percent in August of the possible data were collected. However, for calculating group averages, 78 percent in June, 71 percent in July, and 86 percent in August, 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 the entire day of data 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.

The table below is a summary of three months of data collected in Nashville, Tennessee. The measured monthly electric kWh used by the average solar system is compared to the calculated electric kWh used by a conventional electric water heater (CEWH) that was assumed to be 80-percent efficient and delivered the same thermal load. The current electric rate charged by Nashville Electric Service during the three months ($0.04157/kWh) was used to determine the savings.

	June	July	August
Number of sites per month	17	19	23
Average number persons per site	3.8	3.9	3.7
Average weekday peak reduction (kW) between 10 a.m.-10 p.m.	0.34	0.34	0.35
Maximum average weekday peak reduction (kW, time)	0.63/ 10 p.m.	0.54/ 8 p.m.	0.51/ 9&10 p.m.
Average weekday hot water used (gal)	65.3	66.7	78.8
Average weekend-day hot water used (gal)	70.1	72.0	83.9
Average daily hot water used (gal)	66.6	68.0	80.5

Average daily hot water used per person (gal)	17.5	17.9	21.8
Monthly thermal load delivered (kWh)	258	254	285
Monthly electric kWh used by in 80% efficient (CEWH) (calculated)	322	316	356
Monthly electric kWh used by solar (measured)	112	110	137
Monthly kWh savings (average)	210	206	219
Monthly savings @ $0.04157/kWh April 2, 1981 RS-10 all over 500 kWh	8.73	8.56	9.10
Monthly solar system savings percentage for the average system	65.1	65.3	60.4
Monthly kWh savings (best site)	450	437	510
Average daily hot water used (gal)	143	80	170
Monthly savings ($)	18.71	18.19	21.19

These 23 customers were the first selected as part of a statistical sample based on demographic and system data. A total of 100 sites will be selected and monitored during the program.

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. Three additional systems were approved for sale during June through August 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 one-half of the June through August sales were one-tank systems which are the higher performers.

The next interim monitoring report will analyze data for the period September through November of 1981.

CONTENTS

LIST OF TABLES

LIST OF TABLES (cont.)

LIST OF FIGURES

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 June through August of 1981. Seventeen solar domestic water heater systems (SDWHS) were monitored during May, 19 SDWHS were monitored during June, and 23 SDWHS were monitored in August. 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 during June through August of 1981 does show that all of the SDWHS are operating.

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:

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

[1]The 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 estimates of the proportion in each family size group will be updated.

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.

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 August 1981, 3,844 requests for audits had been received, 834 contracts have been signed, and 629 systems had been installed and passed inspection. A sales summary through August is presented in Table 2 in the Appendix. The manufacturer's name has been replaced by a number. Three additional systems were approved for sale during June through August 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 one-half of the June through August sales were one-tank systems which are the higher performers.

A similar list of the 23 monitored systems presented in this report is shown in Table 3 in the Appendix.

EXPLANATION OF DATA USED

Approximately 98 percent in June, 99 percent in July, and 96 percent in August of the possible data were collected. However, for calculating group averages, 78 percent in June, 71 percent in July, and 86 percent in August, 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 the June through August data.

RESULTS

One of the measured variables, the monthly average weekday water consumption in gallons per day, increased slightly, with 65.3 in June, 66.7 in July, and 78.8 in August. The monthly average number of people per household was 3.8 in June and July, and 3.7 in August. The June, July, and August 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 July profile shows a slight increase in the peaks from June's profile. Whereas, the August profile shows a larger increase in the peaks from July. The August profile also shows a significant increase in water usage in the middle of the day between the two peaks. Interestingly, the monthly average weekend-day water consumption in gallons per day, increased with 70.1 in June, 72.0 in July, and 83.9 in August. The June, July, and August average weekend-day profiles were much more eratic 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 June, July, and August was slightly less than the morning peak.

For a second measured variable Q_{AUX}, the total electrical load used, the monthly average weekday value decreased from 3.7 to 3.5 kWh per day from June to July and then increased to 4.5 kWh per day for August. The electrical load profile for an average weekday in June showed two sharp peaks close together in the morning and gradually decreasing until the next morning's peak started (as shown in Figure 4). Whereas, the July profile had a slightly decreased and flattened morning peak (as shown in Figure 9). Once the July morning peak decreased, the profile gradually decreased until the next morning's peak started. The average weekday August profile shown in Figure 14 is very similar to the July profile except that it is slightly higher due to the increased water consumption. For an average weekend-day, the electrical load profiles for both June and July were similar to the average weekday except the electrical load started two hours later in the morning and the morning peak for both months was a sharp peak. The August average weekend-day electrical load profile was slightly larger and a much smoother profile. This large August profile for the electrical load on an average weekend-day was caused by the increased water consumption on August weekends.

The third measured variable Q_{TOTAL}, the monthly total thermal load supplied to the water stream for an average weekday, decreased slightly from 8.3 to 8.0 kWh/day from June to July and then increased to 9.0 kWh per

day for August. The June, July,and August average weekday Q_{TOTAL} profiles shown in Figures 5, 10, and 15 are similar to the average weekday hot water consumption profiles as were seen in Figures 3, 8, and 13. The decrease in average weekday Q_{TOTAL} from June to July was expected because the water main temperature increased. Whereas, the August increase was somewhat of a surprise--it appeared to be caused by the increased water usage.

The fourth measured variable Q_{SOLAR}, the monthly solar thermal load supplied for an average weekday decreased from 7.0 to 6.5 kWh per day from June to July and then increased to 7.2 kWh per day for August. This was due to the lower energy usage in July and the larger energy usage in August. The June, July, and August average weekday Q_{SOLAR} profiles had a smaller peak in the morning with a larger peak in the evening as shown in Figure 6, 11, and 16. As stated previously, Q_{SOLAR} was only measured for 2-tank systems. In a 2-tank system the collected solar energy is stored in the solar tank. This stored energy is only transferred to the auxiliary tank when hot water is used. Therefore, the larger peak was in the evening when the major hot water useage occurred.

The electrical energy savings to the homeowner, compared to a conventional electric water heater for an average day of the month decreased from 7.0 to 6.7 kWh per day from June to July and increased to 7.1 kWh per day for August. This conventional electric water heater was assumed to be 80 percent efficient and to supply the saved 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 66 percent in June to 60 percent in July and August as presented in Table 7, 12, and 17. The Energy Multiplier, the energy efficiency of the solar system, over the month decreased with 3.23 in June, 3.09 in July, and 2.61 in August.

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 June, July, and August. 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). The average solar system reduced TVA's June hourly electrical demand by an average of 0.34 kW over the twelve hour period with a maximum hourly reduction of 0.63 kW at 10:00 p.m. Whereas, the average solar system reduced TVA's July hourly electrical demand by an average of 0.34 kW during the twelve-hour period with a maximum hourly reduction of 0.54 kW at 8:00 p.m. The average solar system reduced TVA's August hourly electrical demand by an average of 0.36 kW during the twelve hour period with a maximum hourly reduction of 0.51 kW at 10:00 p.m.

Table 19, in the Appendix, summarizes the daily group average data by month. Five months (April through August) 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, and 23 in August. The average monthly daily hot water consumption in gallons per day, has also varied, with 83 in

April, 78 in May, 66 in June, 69 in July, and 79 in August. Another variable, the monthly average total thermal load supplied in kWh per day also fluctuated, with 11.1 in April, 10.3 in May, 8.6 in June, 8.4 in July, and 9.0 in August. 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, and 79 in August.[2] 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 over an 80-percent efficient conventional electric water heater that supplied the same thermal load has remained relatively constant at approximately 7.0 kWh per day except 5.9 kWh per day in May. This was caused by the significantly lower than normal solar insolation available during May. These savings amounted to approximately 30 cents a day to the average customer. 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. Two other systems appeared to have questionable results. A number of sites have such low water consumption that they were underutilized. Consequently, the savings presented here were somewhat less than is expected. However, 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.

Another variable, the Energy Multiplier (E.M.) over the month, fluctuated, with 1.66 in April, 1.56 in May, 3.23 in June, 3.09 in July, and 2.61 in August. This appears to be normal with higher values during the late spring and summer months. The slight decrease in August was caused by the increased water usage for the month. The final variable, Solar Savings Percentage for the month, also fluctuated, with 50.0 in April, 46.0 in May, 65.9 in June, 60.1 in July, and 60.4 in August. This is a little lower than was predicted. However, this has also been decreased by the same problems discussed in the previous paragraph.

DISCLAIMER

This report was prepared by TVA. Neither TVA, or any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, mark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by TVA. The views and opinions of authors expressed herein do not necessarily state or reflect those of TVA.

REFERENCES

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.

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 eifferential 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:

$$\Sigma \text{Gallons}$$

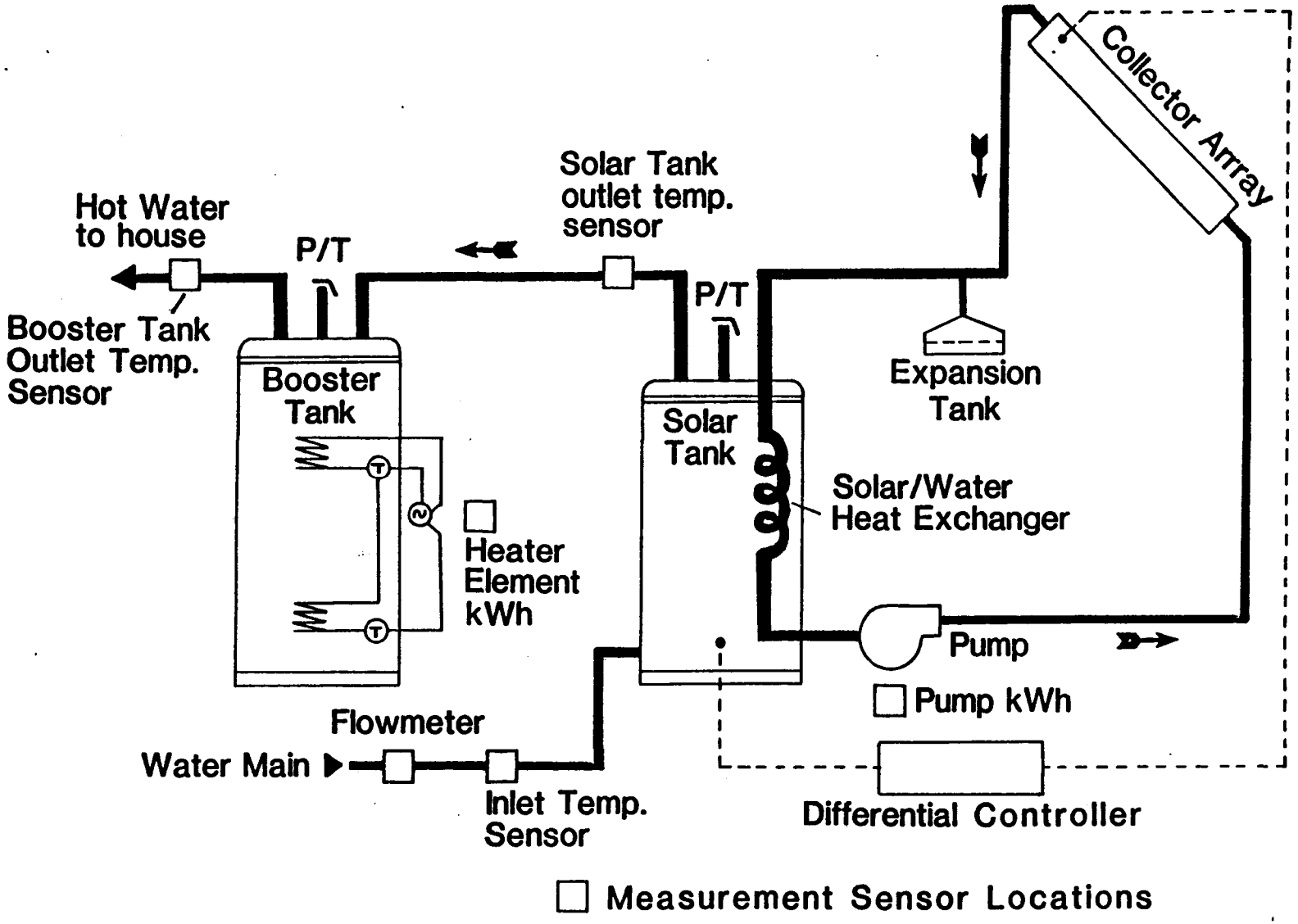

Figure 1. Typical Two Tank System Schematic

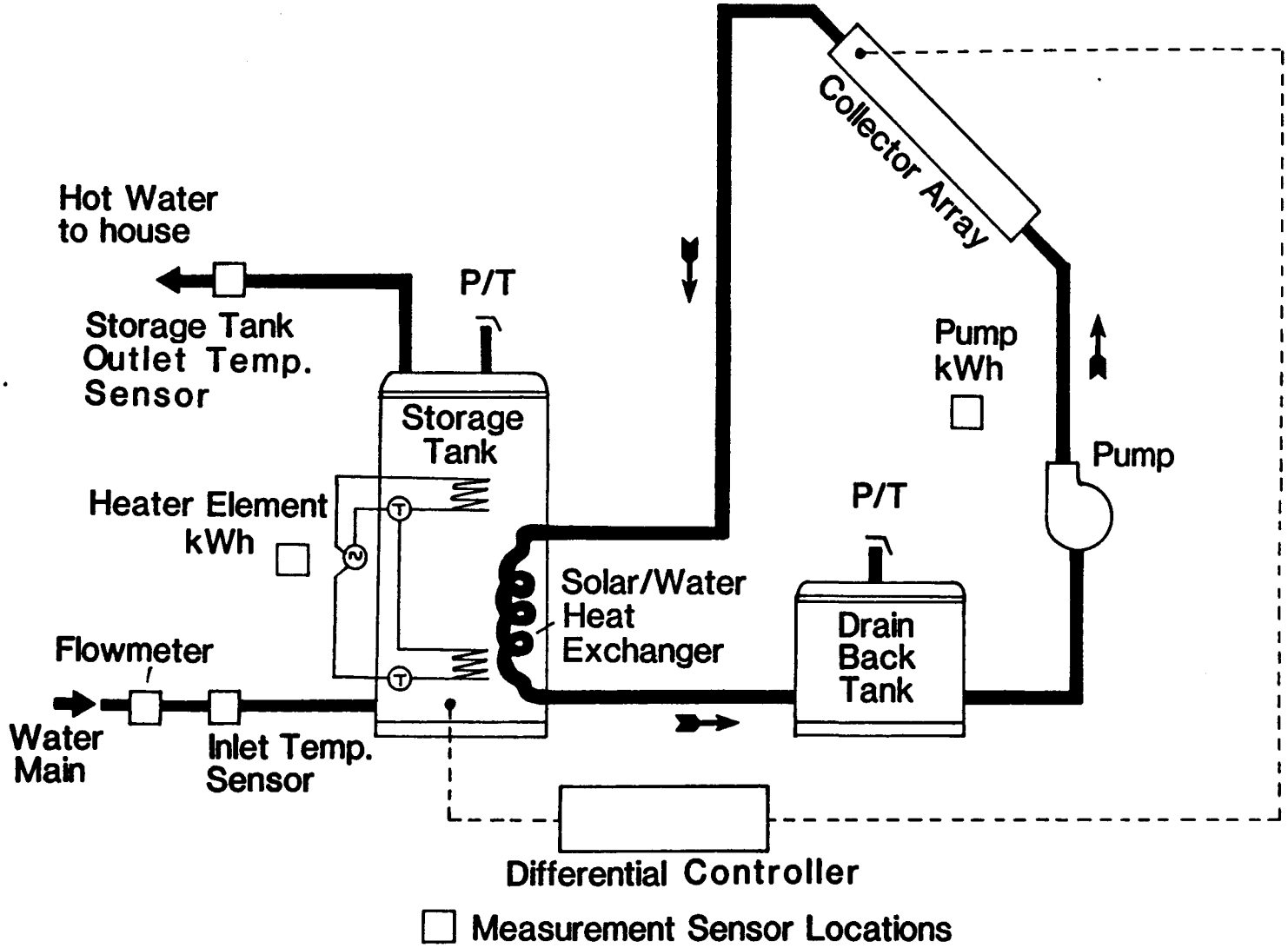

Figure 2. Typical One Tank System Schematic

TVA

Tennessee Valley Authority

Division of Energy Conservation & Rates

System Performance

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

System Checked in Laboratory Test	Estimated Annual Range of Kilowatthour Electrical Energy Replaced by System	Manufacturers' Suggested Installed Price to Consumer
Collect-A-Ray (Mor-Flo) HWSG 48-120	2100 to 2550	$2,900.00
Collect-A-Ray (Mor-Flo) HWSG 72-120	2900 to 3450	3,200.00
Daystar/Solar Energy Master[2]	2500 to 3000	3,200.00
Daystar/Solar Energy Master[3]	3250 to 3900	3,500.00
Grumman (one tank) 332A-MST-82	2400 to 2900	3,695.00
Grumman (two tank) 332A-MST-82	2500 to 3000	3,853.33
InterTechnology Solar Corp (ITC) Joule Box TM-3	2900 to 3500	3,195.00
Northrup/DHW 4120	2500 to 3050	3,325.00
Reynolds/2-1404-ST	3100 to 3700	3,310.00
Reynolds/2-1454-ST	3650 to 4400	3,625.00
Rheem Ruud (insulated)/SDD82T	3100 to 3750	3,850.00
Rheem Ruud (uninsulated)/SDD82T	2550 to 3050	3,850.00
Solar One/4-16-82-2	2050 to 2450	2,665.00
Solar One/5-16-82-2	2450 to 2950	2,975.00
Solarstream (Mor-Flo) HWSG 48-120	2100 to 2550	2,900.00
Solarstream (Mor-Flo) HWSG 72-120	2900 to 3450	3,200.00
Solar Unlimited/4DP	2250 to 2700	3,257.00
Sunmaster Corp/Dec-8A/4	2800 to 3400	3,375.00
Sunworks/Solector Pak 1000/3	2150 to 2550	3,280.00
U.S. Solar Corp/D-120-80	4350 to 5250	3,596.00
U.S. Solar Corp/D-120-80-DW	3950 to 4750	3,836.30

- The estimated annual range of kilowatthour equivalent energy delivered by solar is based on laboratory tests for hot water use of 66 to 80 gallons per day. Results for the homeowner will vary depending on the amount of water used, when it is used, and weather conditions. Conventional electric water heaters will require approximatel 5340 to 6614 kilowatthours under comparable conditions. Ask the solar advisor for an estimate of savings for hot water use deviating from the standard consumption estimated. Savings will increase with increased hot water use.

- The homeowner should also consider maintenance costs when selecting a solar water heater. Ask the contractor's representative for this information.

- The contractor's quoted price may vary due to 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 $3,400.00.

- In order to increase energy savings, it is to the consumers' benefit to keep the electric heating element supply off as much as possible while satisying hot water needs.

Issued July 13, 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 AUGUST 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	Internal single wall	1	Drainback	34	5.1	107	16.1	29	4.4	170
5	nonfreezing	External double wall	2	--	26	3.9	81	12.2	22	3.3	129
16	nonfreezing	External double wall	2	--	17	2.6	52	7.8	14	2.1	83
11	nonfreezing	External double wall	2	--	19	2.9	60	9.0	16	2.4	95
18	nonfreezing	External double wall	2	--	19	2.9	59	8.9	16	2.4	94
7	water	Internal single wall	2	Drainback	5	0.8	16	2.4	4	0.6	25
8	nonfreezing	External double wall	2	--	4	0.6	12	1.8	3	0.5	19
19	nonfreezing	Internal double wall	2	--	0	0.0	1	0.2	0	0.0	1
12	water	None	2	Direct Drainback	7	1.1	23	3.5	6	0.9	36
22	water	Internal single wall	1	Drainback	3	0.5	9	1.4	2	0.3	14
TOTAL					133	20.0	420	63.1	113	17.0	666

Note: All systems use flat-plate collectors.

TABLE 3. ALLOCATION BY MANUFACTURER AND FAMILY SIZE FOR THE 23 MONITORED SYSTEMS

MFG. NO.	FAMILY SIZE 1-2	% OF TOTAL	FAMILY SIZE 3-4	% OF TOTAL	FAMILY SIZE 5+	% OF TOTAL	TOTAL
2	1	4.3	1	4.3	2	8.7	4
5	3	13.0	3	13.0	2	8.7	8
16	1	4.3	3	13.0	1	4.3	5
18	0	0.0	2	8.7	0	0.0	2
11	0	0.0	3	13.0	0	0.0	3
8	0	0.0	1	4.3	0	0.0	1
TOTAL	5	21.6	13	56.3	5	21.7	23

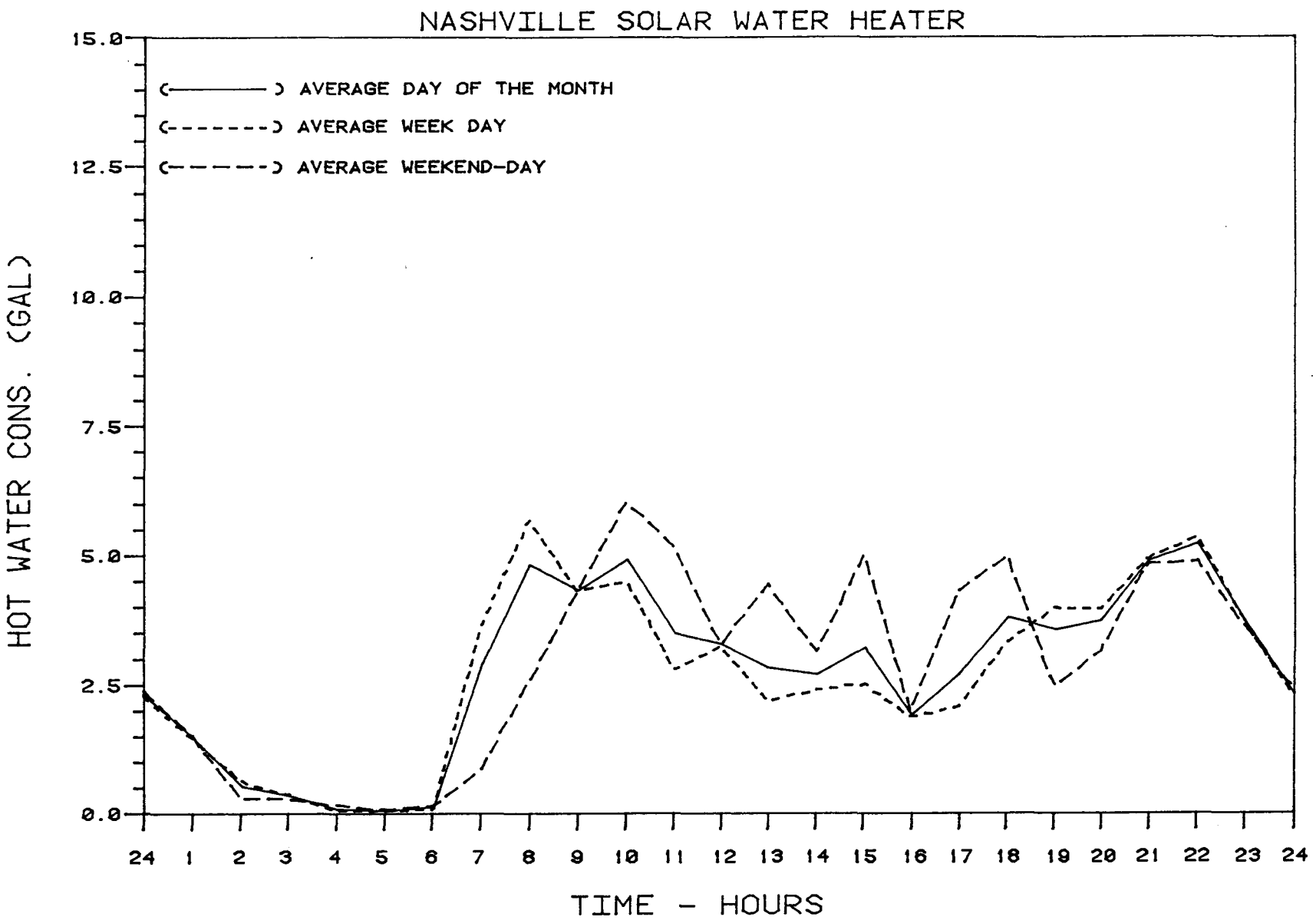

FIGURE 3 PROFILE OF AVERAGE HOT WATER CONSUMPTION FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR JUNE 1981

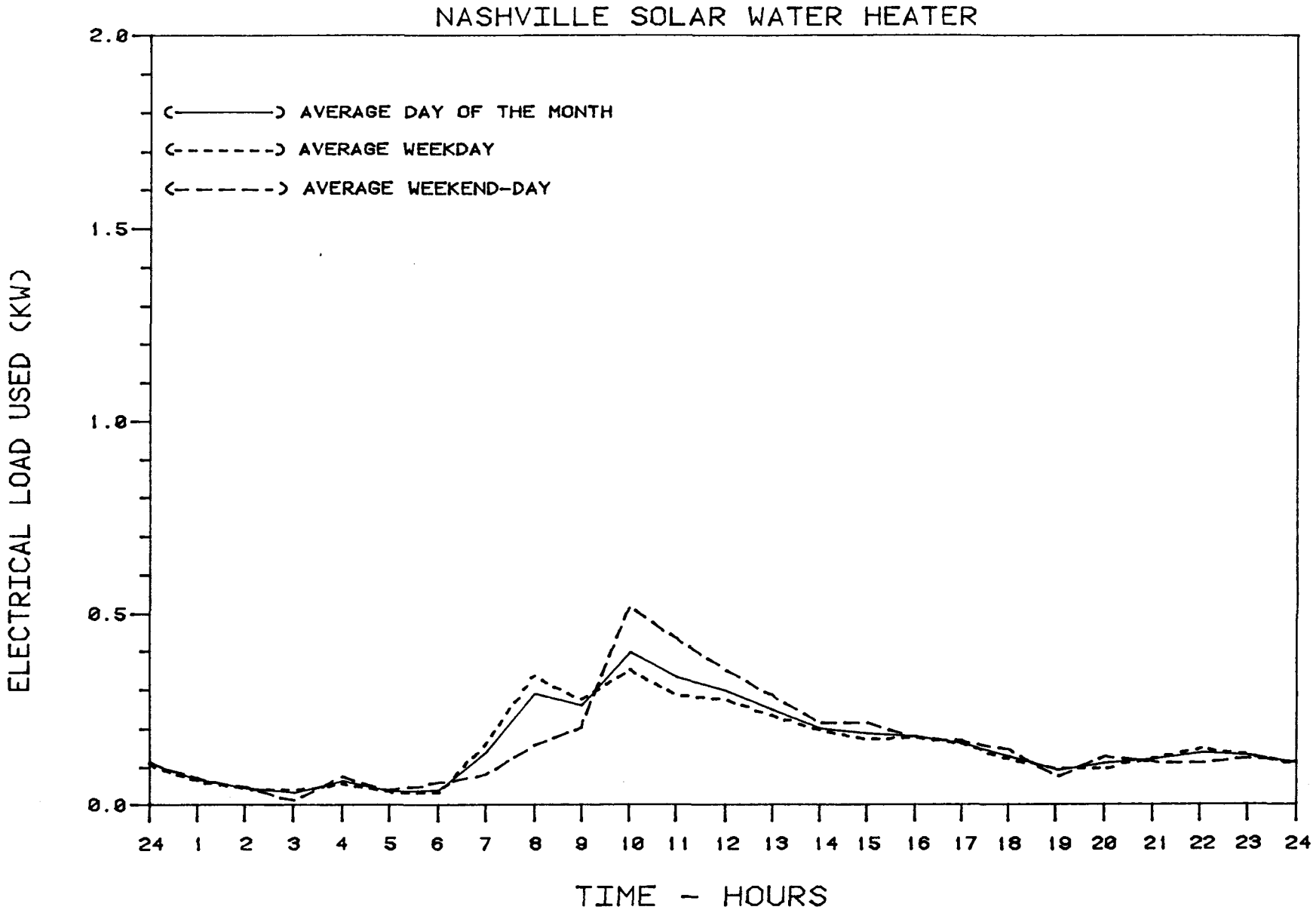

FIGURE 4 PROFILE OF AVERAGE ELECTRICAL LOAD USED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR JUNE 1981

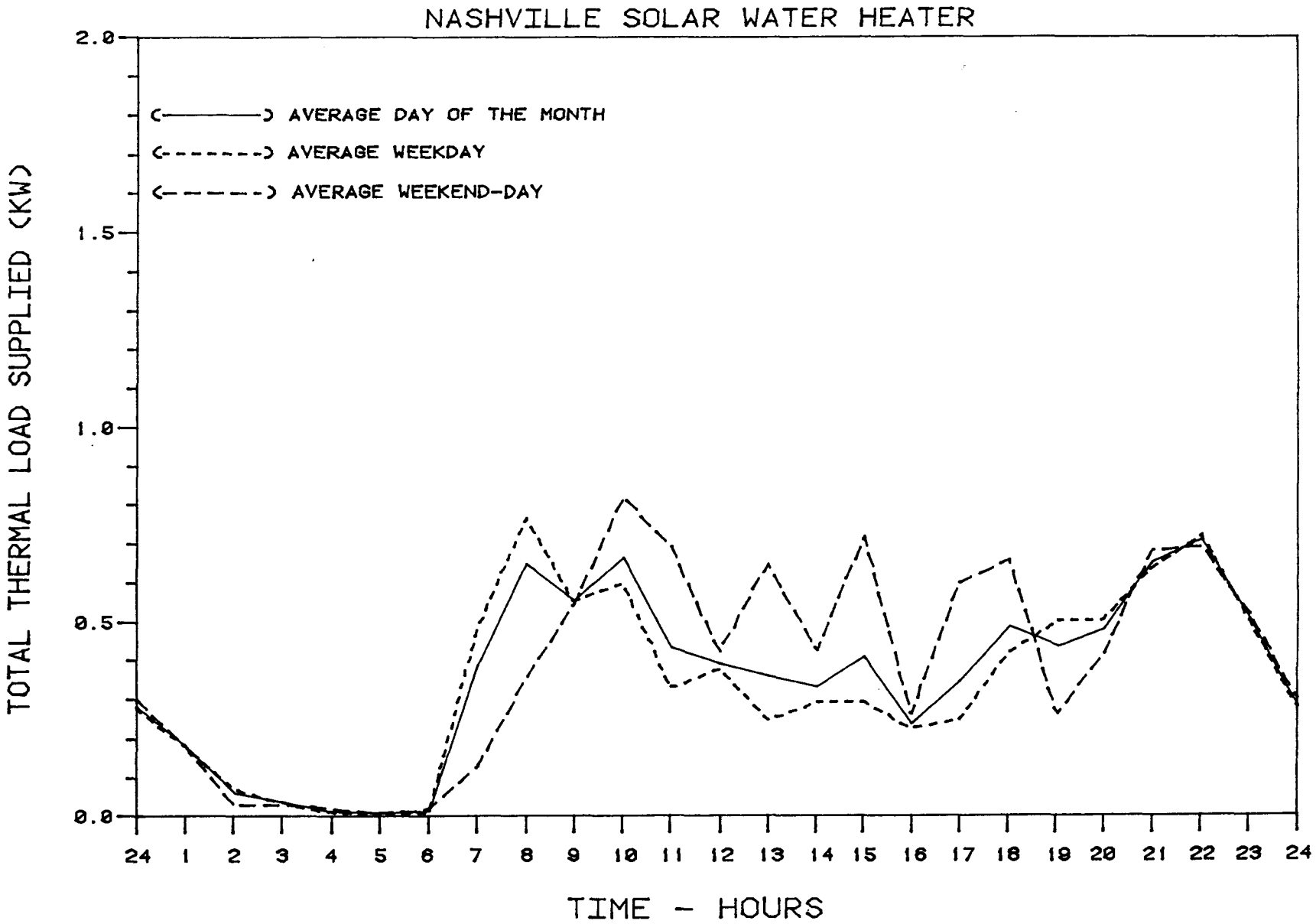

FIGURE 5 PROFILE OF AVERAGE TOTAL THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR JUNE 1981

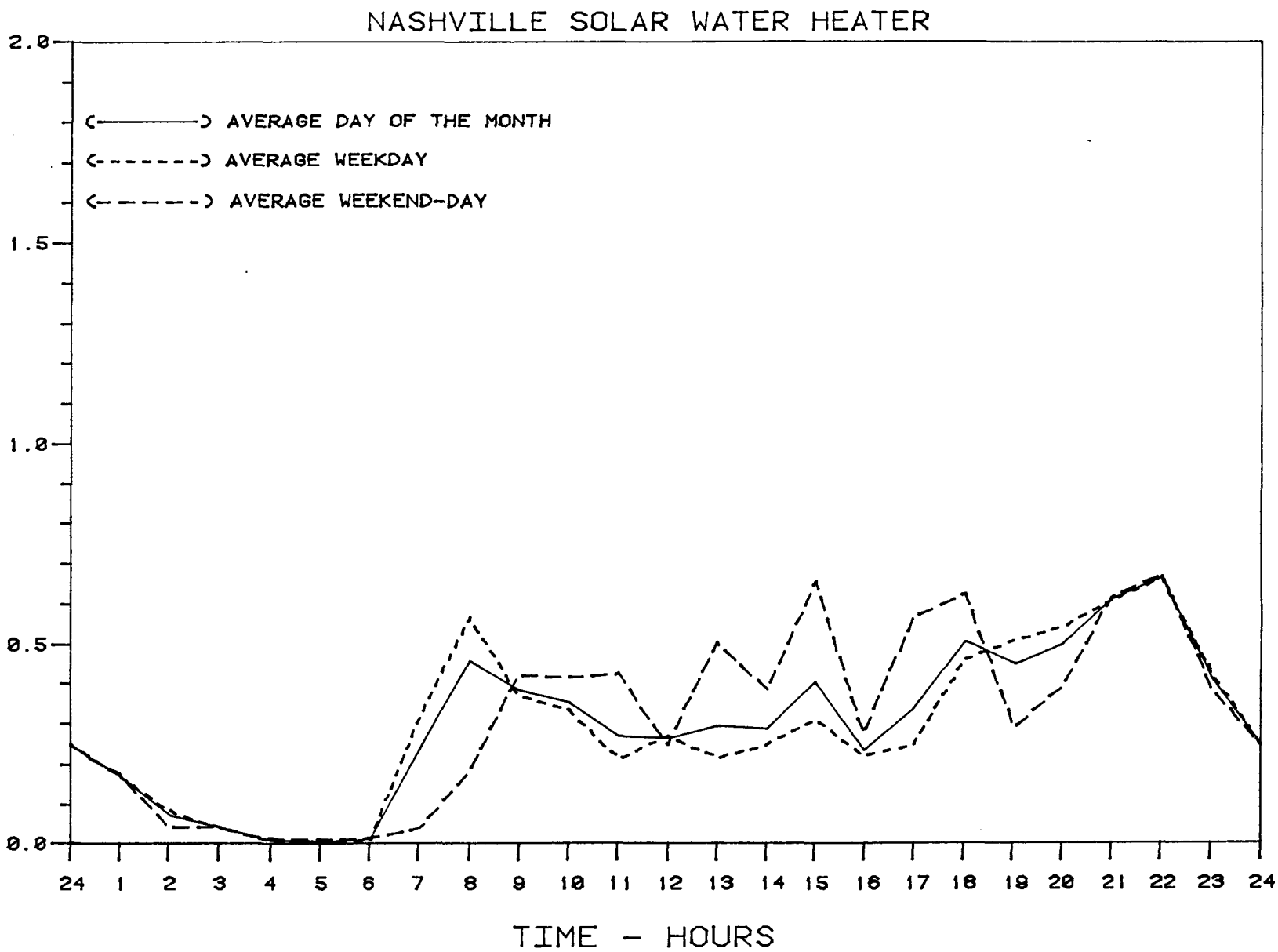

FIGURE 6 PROFILE OF AVERAGE SOLAR THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR JUNE 1981

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.170	0.189	0.070	1.513
2:00	0.062	0.057	0.044	0.502
3:00	0.035	0.033	0.036	0.315
4:00	0.007	0.011	0.060	0.085
5:00	0.003	0.006	0.036	0.054
6:00	0.009	0.013	0.044	0.112
7:00	0.239	0.387	0.141	2.907
8:00	0.460	0.653	0.304	4.869
9:00	0.366	0.546	0.270	4.260
10:00	0.336	0.640	0.393	4.745
11:00	0.268	0.446	0.343	3.557
12:00	0.265	0.410	0.315	3.354
13:00	0.286	0.360	0.260	2.825
14:00	0.265	0.303	0.204	2.493
15:00	0.393	0.392	0.187	3.095
16:00	0.235	0.239	0.184	1.909
17:00	0.336	0.341	0.169	2.680
18:00	0.498	0.477	0.127	3.721
19:00	0.446	0.434	0.093	3.530
20:00	0.511	0.508	0.116	3.925
21:00	0.613	0.665	0.123	5.000
22:00	0.661	0.718	0.142	5.238
23:00	0.414	0.508	0.135	3.713
24:00	0.249	0.297	0.113	2.400
TOTAL	7.125	8.634	3.907	66.803

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 66.803 GALLONS
AVERAGE ELECTRICAL LOAD USED = 3.907 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 8.634 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 7.125 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.29
AVERAGE DAILY THERMAL LOAD SAVED = 6.89 KWH

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.172	0.194	0.069	1.533
2:00	0.072	0.069	0.044	0.591
3:00	0.036	0.034	0.045	0.342
4:00	0.006	0.008	0.054	0.058
5:00	0.002	0.005	0.034	0.048
6:00	0.008	0.012	0.035	0.106
7:00	0.313	0.488	0.165	3.693
8:00	0.563	0.768	0.353	5.729
9:00	0.359	0.561	0.294	4.349
10:00	0.317	0.587	0.353	4.379
11:00	0.209	0.346	0.304	2.906
12:00	0.268	0.392	0.288	3.280
13:00	0.217	0.267	0.246	2.291
14:00	0.238	0.276	0.199	2.274
15:00	0.309	0.290	0.177	2.488
16:00	0.215	0.219	0.182	1.822
17:00	0.254	0.246	0.163	2.063
18:00	0.462	0.424	0.116	3.314
19:00	0.504	0.494	0.095	3.907
20:00	0.561	0.544	0.103	4.207
21:00	0.618	0.664	0.122	5.092
22:00	0.657	0.721	0.150	5.319
23:00	0.422	0.498	0.131	3.695
24:00	0.252	0.293	0.110	2.381
TOTAL	7.034	8.396	3.834	65.867

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 65.867 GALLONS
AVERAGE ELECTRICAL LOAD USED = 3.834 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 8.396 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 7.034 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.28
AVERAGE DAILY THERMAL LOAD SAVED = 6.66 KWH

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.165	0.178	0.075	1.457
2:00	0.033	0.025	0.042	0.258
3:00	0.033	0.028	0.010	0.241
4:00	0.008	0.019	0.074	0.158
5:00	0.006	0.009	0.043	0.072
6:00	0.013	0.018	0.067	0.130
7:00	0.034	0.109	0.074	0.747
8:00	0.178	0.338	0.169	2.504
9:00	0.383	0.504	0.204	4.014
10:00	0.388	0.786	0.502	5.751
11:00	0.430	0.723	0.450	5.347
12:00	0.259	0.460	0.391	3.556
13:00	0.475	0.618	0.298	4.293
14:00	0.341	0.379	0.216	3.095
15:00	0.621	0.673	0.213	4.765
16:00	0.289	0.293	0.191	2.149
17:00	0.561	0.603	0.186	4.379
18:00	0.597	0.622	0.157	4.840
19:00	0.285	0.267	0.086	2.494
20:00	0.373	0.411	0.153	3.148
21:00	0.599	0.668	0.123	4.748
22:00	0.674	0.710	0.120	5.017
23:00	0.390	0.537	0.146	3.763
24:00	0.240	0.309	0.120	2.450
TOTAL	7.376	9.290	4.110	69.376

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 69.376 GALLONS
AVERAGE ELECTRICAL LOAD USED = 4.110 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 9.290 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 7.376 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.31
AVERAGE DAILY THERMAL LOAD SAVED = 7.50 KWH

TABLE 7 - SUMMARY OF DATA BY SITE FOR JUNE 1981

Site No.	Mfg. No.	Family Size	No. of Days of Data	Q_{SOLAR} (kWh)	Q_{TOTAL} (kWh)	Q_{AUX} (kWh)	Water Consumption (Gal)	Total Energy Saved by System (kWh)	Total Savings ($)	Energy Multiplier (EM)	Solar System Savings Percentage %
1	18	4	30	182	213	121	1,721	144	6.00	1.75	54.3
2	5	2	26	309	244	34	2,351	271	11.27	7.22	88.9
3**	5	2	30	148	172	135	1,507	80	3.32	1.27	37.1
4	5	2	28	149	116	51	960	94	3.89	2.26	64.6
5	18	4	21	143	198	165	1,513	83	3.46	1.20	33.6
6*	5	6	30	18	17	98	258	-77	-3.18	0.18	--
7	16	4	30	182	324	161	2,431	244	10.13	2.01	60.2
8	16	4	28	123	248	166	1.473	144	5.98	1.49	46.5
9	2	3	21	N/A	131	21	766	143	5.95	6.24	87.2
15	5	3	28	260	342	61	1.981	366	15.22	5.61	85.7
11	5	5	13	159	97	17	1,561	104	4.32	5.70	86.0
12	11	3	30	260	306	88	2,423	294	12.24	3.49	77.1
13*	2	5	18	N/A	0	25	969	-25	-1.02	--	--
14	16	5	13	154	280	154	1,862	195	8.13	1.82	55.9
15	16	4	12	69	63	18	677	61	2.54	3.55	77.4
16	16	2	14	40	29	11	296	25	1.04	2.59	69.1
17	2	7	5	N/A	67	30	379	54	2.26	2.26	64.6

*denotes not included in total or average.
**denotes differential controller malfunction.

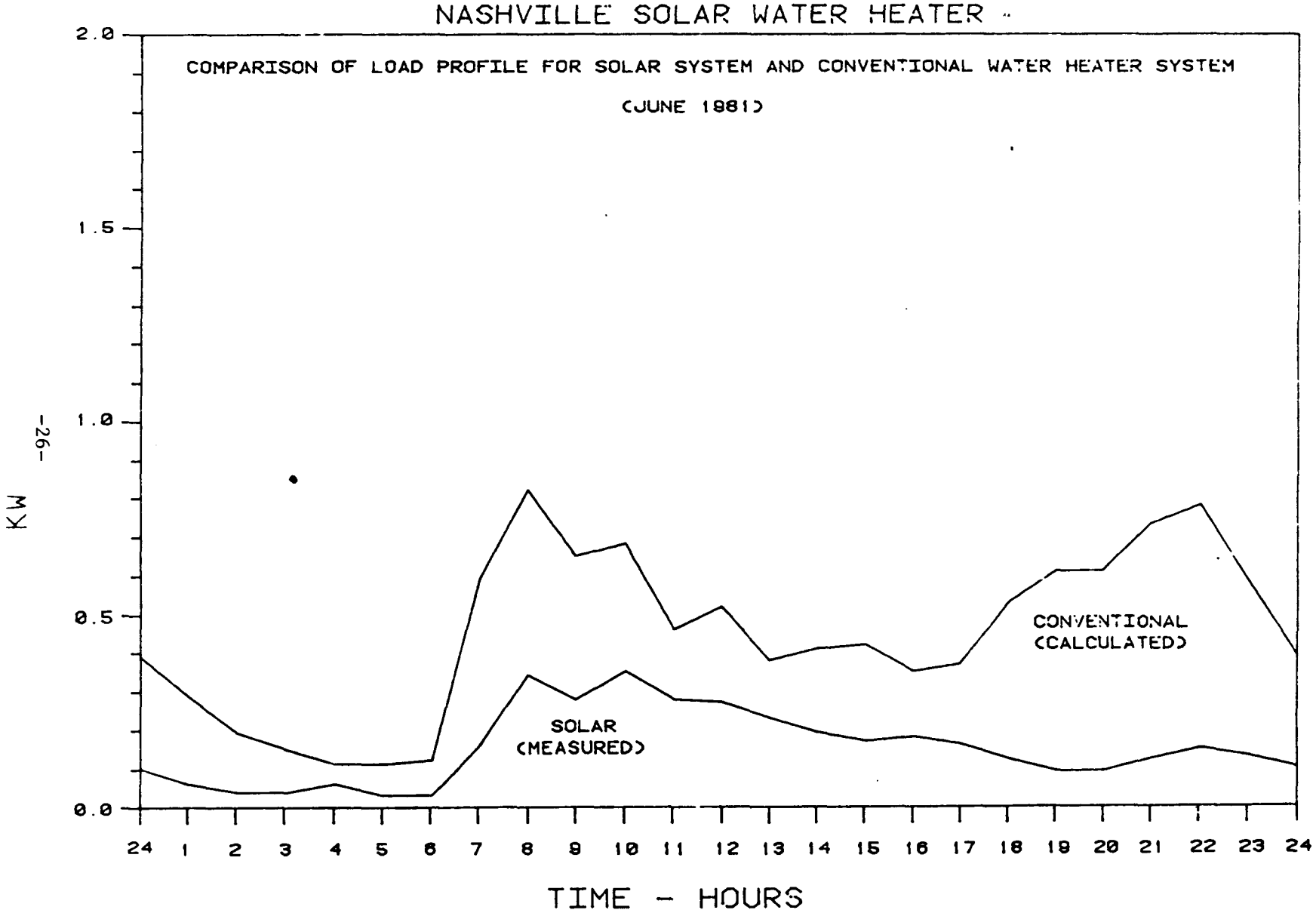

FIGURE 7 AVERAGE WEEKDAY PROFILE OF ELECTRICAL LOAD FOR AVERAGE SOLAR SYSTEM AND CONVENTIONAL WATER HEATER SYSTEM FOR JUNE 1981

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 JUNE 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	1.47	0.29
2	0.04	0.62	0.19
3	0.04	0.37	0.15
4	0.06	0.06	0.11
5	0.03	0.05	0.11
6	0.03	0.11	0.12
7	0.16	3.65	0.59
8	0.34	5.65	0.82
9	0.28	4.31	0.65
10	0.35	4.48	0.68
11*	0.28	2.80	0.46
12*	0.27	3.24	0.52
13*	0.23	2.19	0.38
14*	0.19	2.39	0.41
15*	0.17	2.50	0.42
16*	0.18	1.88	0.35
17*	0.16	2.05	0.37
18*	0.12	3.30	0.53
19*	0.09	3.97	0.61
20*	0.09	3.95	0.61
21*	0.12	4.92	0.73
22*	0.15	5.34	0.78
23	0.13	3.69	0.58
24	0.10	2.26	0.39
Total	3.67	65.25	10.85
On Peak Totals	2.05		6.17

*denotes on peak

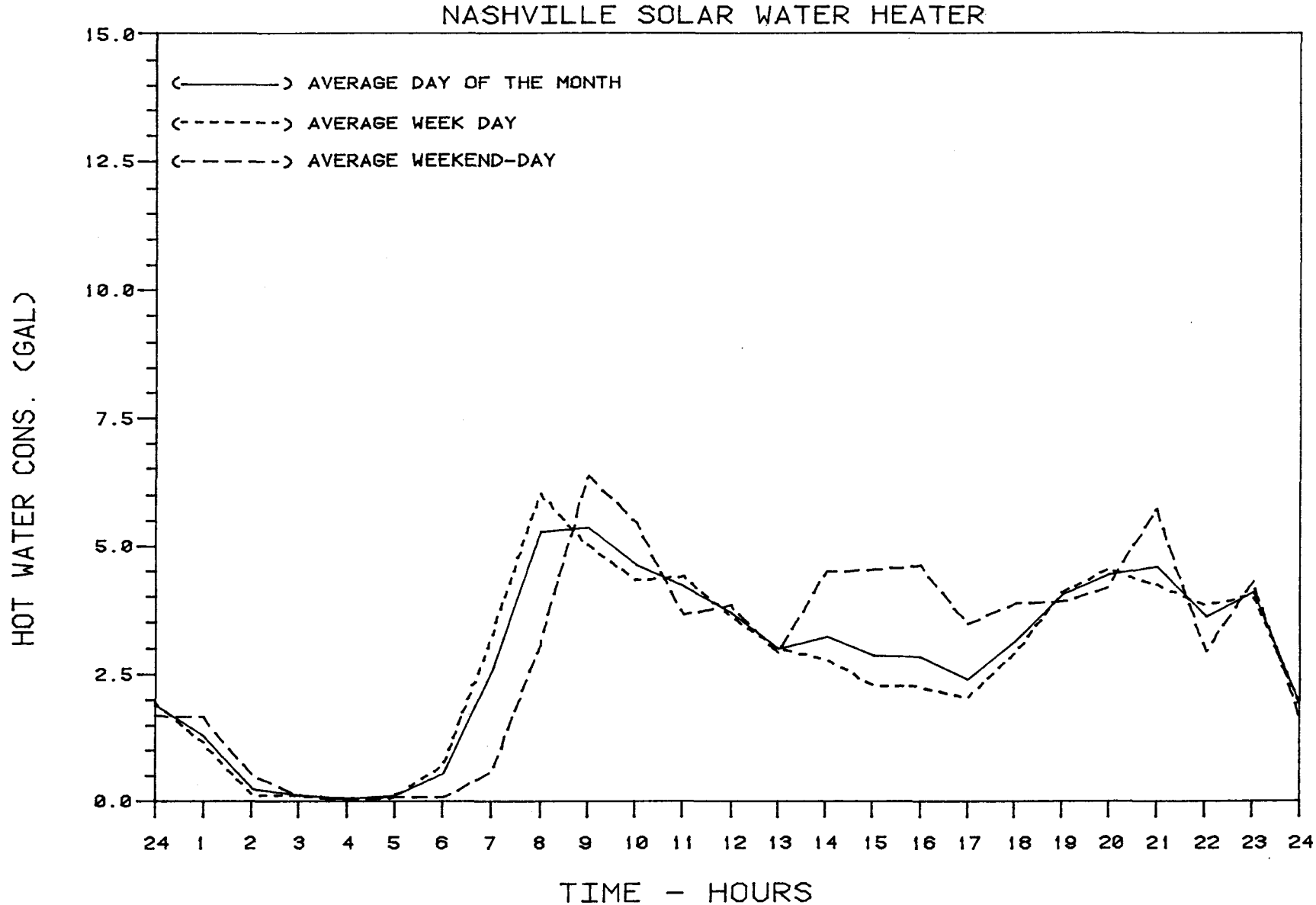

FIGURE 8 PROFILE OF AVERAGE HOT WATER CONSUMPTION FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR JULY 1981

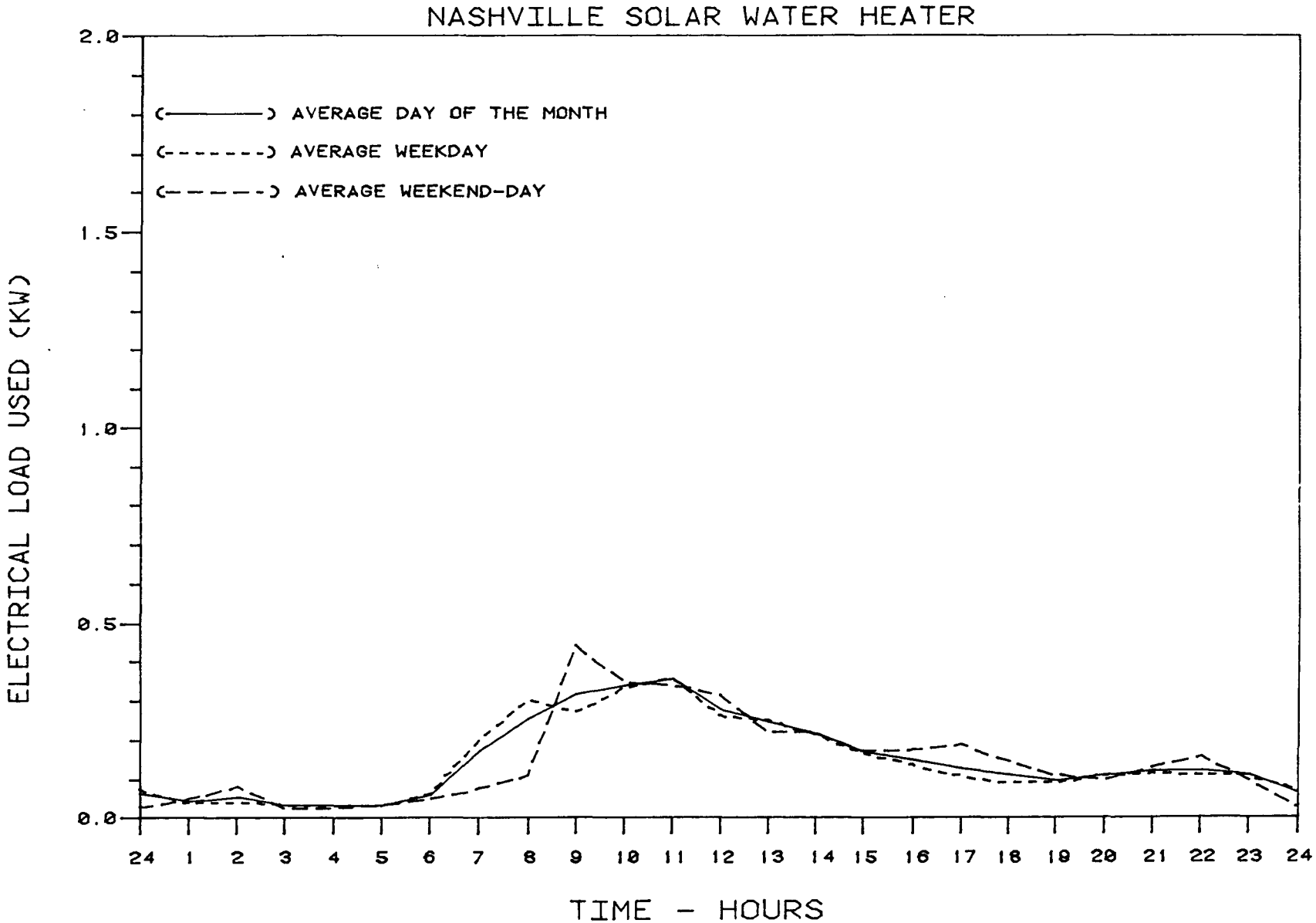

FIGURE 9 PROFILE OF AVERAGE ELECTRICAL LOAD USED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR JULY 1981

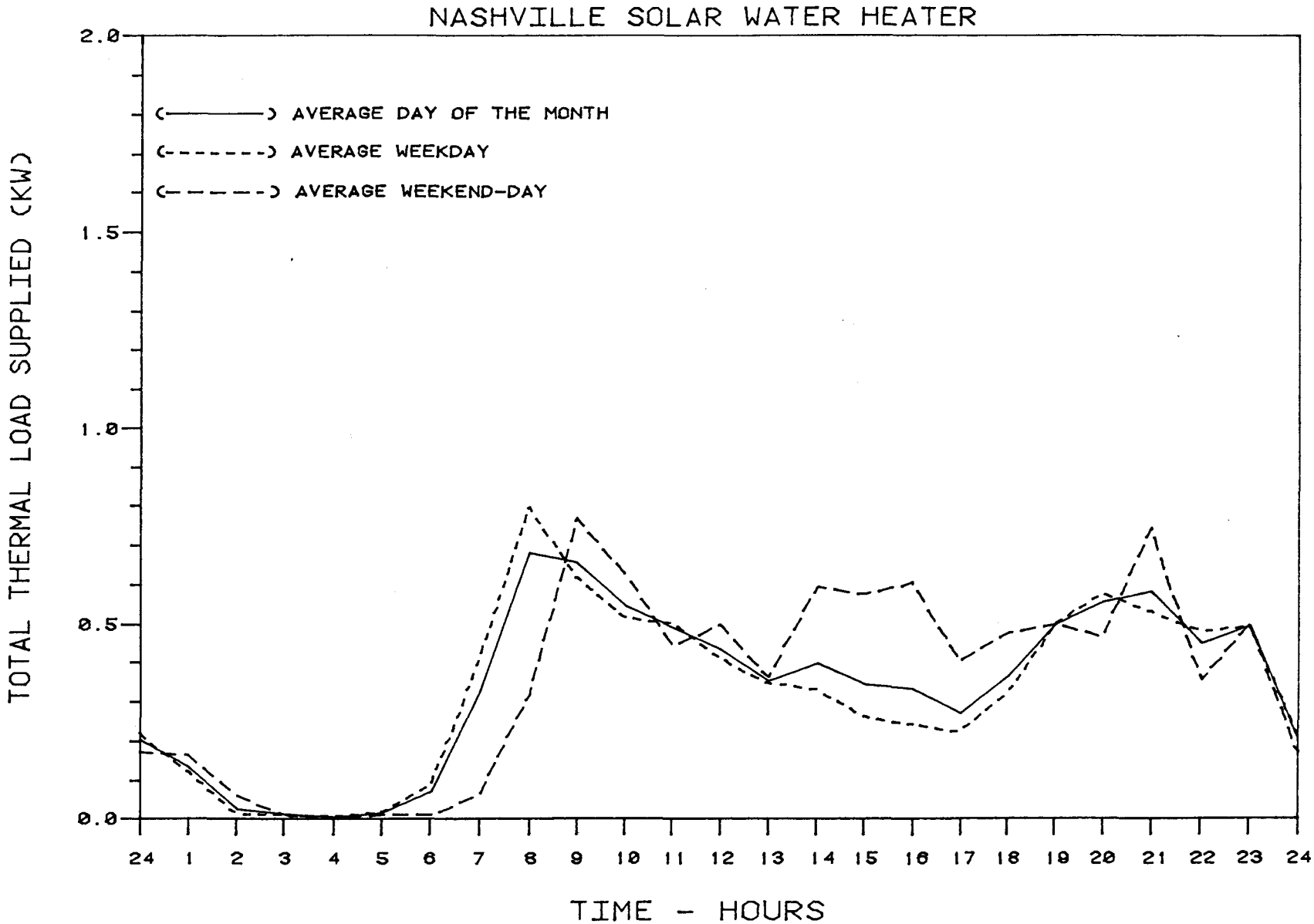

FIGURE 10 PROFILE OF AVERAGE TOTAL THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR JULY 1981

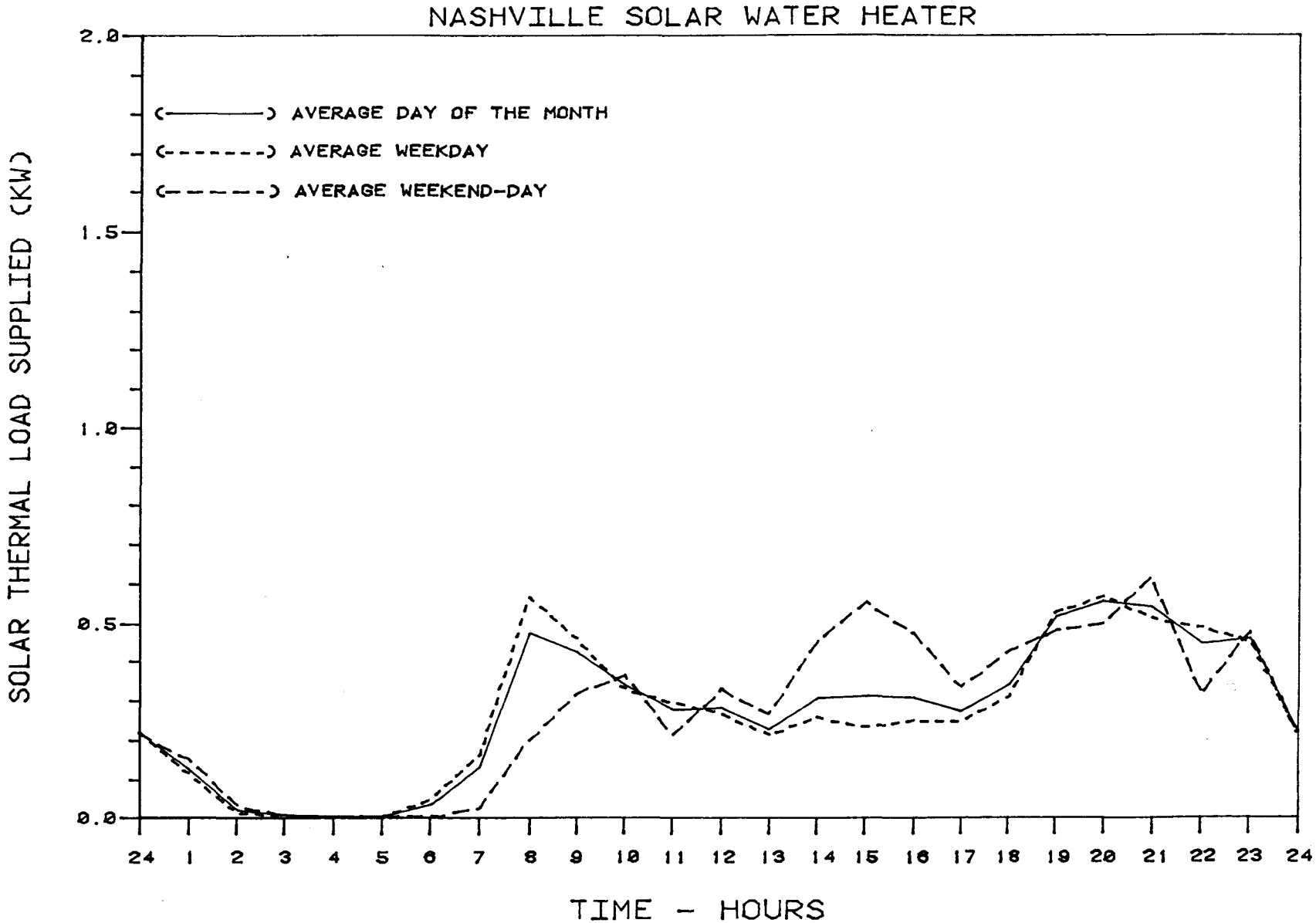

FIGURE 11 PROFILE OF AVERAGE SOLAR THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR JULY 1981

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.116	0.127	0.044	1.215
2:00	0.018	0.026	0.055	0.232
3:00	0.006	0.009	0.033	0.092
4:00	0.004	0.005	0.032	0.048
5:00	0.005	0.014	0.034	0.101
6:00	0.035	0.069	0.059	0.556
7:00	0.129	0.324	0.169	2.551
8:00	0.462	0.670	0.248	5.231
9:00	0.425	0.660	0.317	5.389
10:00	0.333	0.538	0.335	4.560
11:00	0.267	0.478	0.348	4.108
12:00	0.275	0.424	0.272	3.573
13:00	0.223	0.348	0.240	2.911
14:00	0.306	0.397	0.209	3.201
15:00	0.314	0.343	0.164	2.842
16:00	0.310	0.337	0.146	2.849
17:00	0.268	0.268	0.126	2.359
18:00	0.339	0.367	0.107	3.142
19:00	0.506	0.495	0.095	4.011
20:00	0.539	0.548	0.106	4.402
21:00	0.536	0.581	0.119	4.572
22:00	0.430	0.440	0.121	3.527
23:00	0.448	0.483	0.101	3.967
24:00	0.205	0.195	0.062	1.763
TOTAL	6.501	8.145	3.541	67.199

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 67.199 GALLONS
AVERAGE ELECTRICAL LOAD USED = 3.541 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 8.145 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 6.501 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.28
AVERAGE DAILY THERMAL LOAD SAVED = 6.64 KWH

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.112	0.119	0.040	1.119
2:00	0.014	0.014	0.043	0.132
3:00	0.006	0.008	0.036	0.087
4:00	0.005	0.006	0.033	0.052
5:00	0.005	0.015	0.032	0.112
6:00	0.046	0.090	0.062	0.719
7:00	0.164	0.413	0.200	3.231
8:00	0.552	0.787	0.295	5.947
9:00	0.461	0.612	0.269	4.981
10:00	0.320	0.505	0.327	4.257
11:00	0.287	0.491	0.350	4.292
12:00	0.259	0.401	0.256	3.537
13:00	0.208	0.343	0.246	2.943
14:00	0.253	0.327	0.207	2.752
15:00	0.226	0.255	0.161	2.218
16:00	0.250	0.238	0.135	2.213
17:00	0.246	0.222	0.104	1.993
18:00	0.310	0.325	0.092	2.884
19:00	0.524	0.498	0.090	4.093
20:00	0.564	0.579	0.106	4.523
21:00	0.509	0.525	0.114	4.190
22:00	0.476	0.470	0.103	3.756
23:00	0.443	0.481	0.102	3.938
24:00	0.213	0.209	0.073	1.886
TOTAL	6.452	7.933	3.475	65.855

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 65.855 GALLONS
AVERAGE ELECTRICAL LOAD USED = 3.475 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 7.933 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 6.452 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.27
AVERAGE DAILY THERMAL LOAD SAVED = 6.44 KWH

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.126	0.149	0.053	1.491
2:00	0.031	0.059	0.089	0.520
3:00	0.007	0.011	0.026	0.106
4:00	0.004	0.003	0.030	0.036
5:00	0.005	0.009	0.037	0.069
6:00	0.005	0.010	0.049	0.086
7:00	0.029	0.068	0.079	0.596
8:00	0.203	0.333	0.115	3.171
9:00	0.321	0.800	0.455	6.562
10:00	0.370	0.631	0.360	5.430
11:00	0.209	0.443	0.342	3.580
12:00	0.321	0.492	0.319	3.677
13:00	0.265	0.362	0.223	2.820
14:00	0.460	0.600	0.215	4.491
15:00	0.568	0.595	0.172	4.636
16:00	0.485	0.620	0.176	4.676
17:00	0.330	0.400	0.192	3.411
18:00	0.422	0.485	0.152	3.884
19:00	0.456	0.486	0.109	3.774
20:00	0.468	0.459	0.105	4.054
21:00	0.612	0.742	0.135	5.672
22:00	0.299	0.352	0.172	2.868
23:00	0.461	0.489	0.095	4.048
24:00	0.184	0.155	0.029	1.409
TOTAL	6.640	8.754	3.730	71.065

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 71.065 GALLONS
AVERAGE ELECTRICAL LOAD USED = 3.730 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 8.754 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 6.640 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.30
AVERAGE DAILY THERMAL LOAD SAVED = 7.21 KWH

TABLE 12 - SUMMARY OF DATA BY SITE FOR JULY 1981

Site No.	Mfg. No.	Family Size	No. of Days of Data	Q_{SOLAR} (kWh)	Q_{TOTAL} (kWh)	Q_{AUX} (kWh)	Water Consumption (Gal)	Total Energy Saved by System (kWh)	Total Savings ($)	Energy Multiplier (EM)	Solar System Savings Percentage %
1	18	4	31	174	180	91	1,569	135	5.60	1.99	59.7
2	5	2	22	277	212	23	2,170	242	10.05	9.25	91.3
3**	5	5	31	152	168	184	1,779	26	1.09	.91	12.5
4	5	2	30	192	147	55	1,358	128	5.34	2.65	69.8
5	18	4	24	169	153	57	1,709	134	5.58	2.68	70.1
6	5	6	2	48	25	33	326	- 1	-.05	0.77	-4.0
7**	16	4	30	134	241	134	2,005	167	6.94	1.80	55.5
8	16	4	31	100	175	133	1,141	86	3.56	1.32	39.2
9	2	3	17	N/A	148	22	914	164	6.80	6.82	88.3
10	5	3	31	292	426	95	2,492	437	18.19	4.49	82.2
11	5	5	7	71	46	8	821	49	2.04	5.84	86.3
12	11	3	31	182	199	52	1,668	197	8.19	3.83	79.1
13*	2	5	31	N/A	14	77	3,440	-59	-2.46	0.18	--
14*	16	5	31	1,091	692	416	4,721	449	18.68	1.66	51.9
15	16	4	31	298	413	155	3,800	361	15.02	2.67	70.0
16	16	2	31	87	63	28	665	50	2.09	2.23	64.2
17	2	7	31	N/A	507	273	3,279	360	14.96	1.85	56.8
18	11	6	2	14	17	8	148	13	0.53	2.06	61.1
19	8	3	1	3	1	1	19	1	0.04	1.34	40.1

*denotes not included in total or average.
**denotes differential controller malfunction.

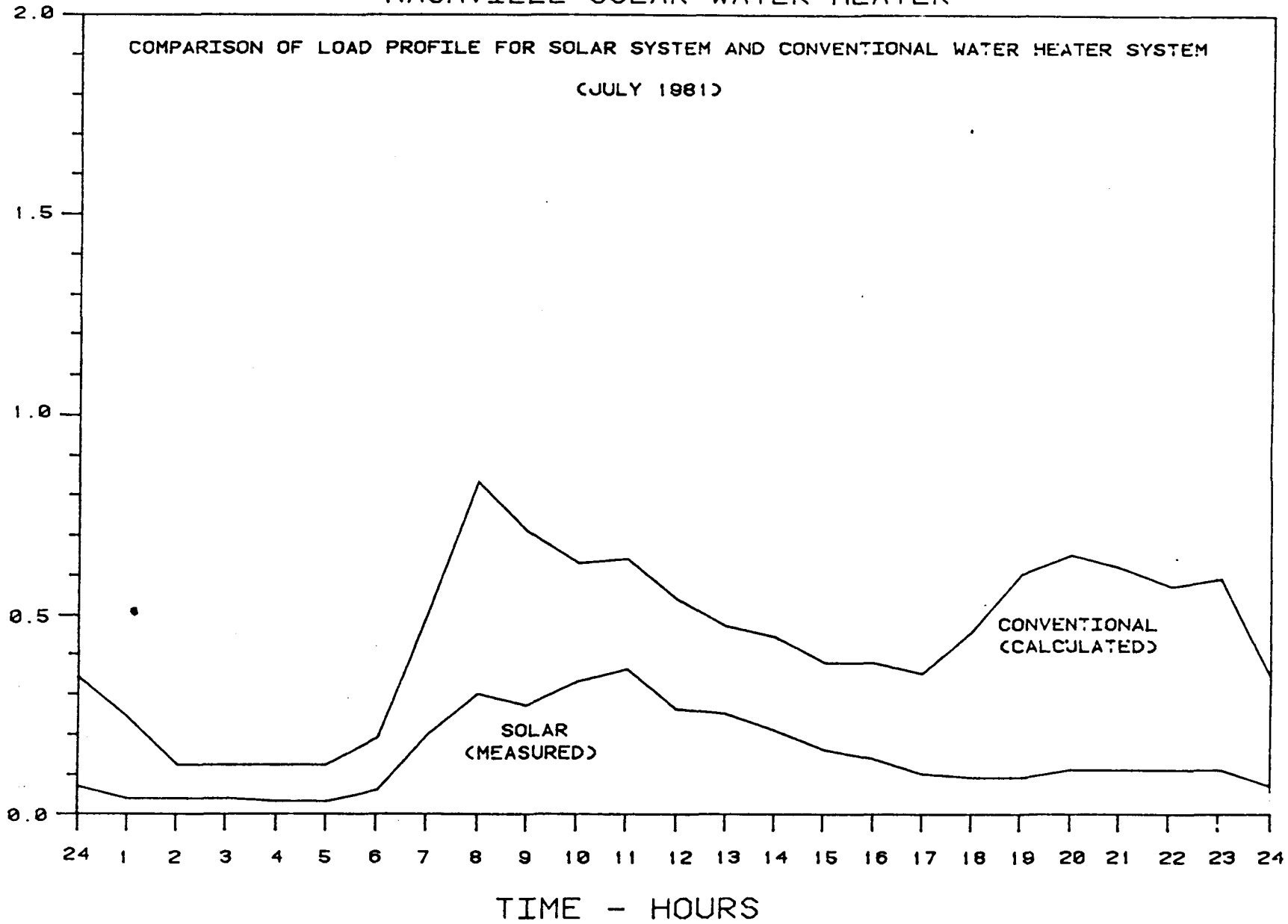

FIGURE 12 AVERAGE WEEKDAY PROFILE OF ELECTRICAL LOAD FOR AVERAGE SOLAR SYSTEM AND CONVENTIONAL WATER HEATER SYSTEM FOR JULY 1981

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 JULY 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	0.04	1.16	0.25
2	0.04	0.13	0.12
3	0.04	0.09	0.12
4	0.03	0.05	0.12
5	0.03	0.11	0.12
6	0.06	0.71	0.19
7	0.20	3.25	0.50
8	0.30	6.00	0.83
9	0.27	5.00	0.71
10	0.33	4.33	0.63
11*	0.36	4.40	0.64
12*	0.26	3.62	0.54
13*	0.25	2.98	0.47
14*	0.21	2.79	0.44
15*	0.16	2.27	0.38
16*	0.14	2.23	0.38
17*	0.10	2.00	0.35
18*	0.09	2.89	0.46
19*	0.09	4.09	0.60
20*	0.11	4.53	0.65
21*	0.11	4.22	0.62
22*	0.11	3.82	0.57
23	0.11	4.04	0.59
24	0.07	1.93	0.34
Total	3.51	66.64	10.62
On Peak Totals	1.99		6.10

*denotes on peak

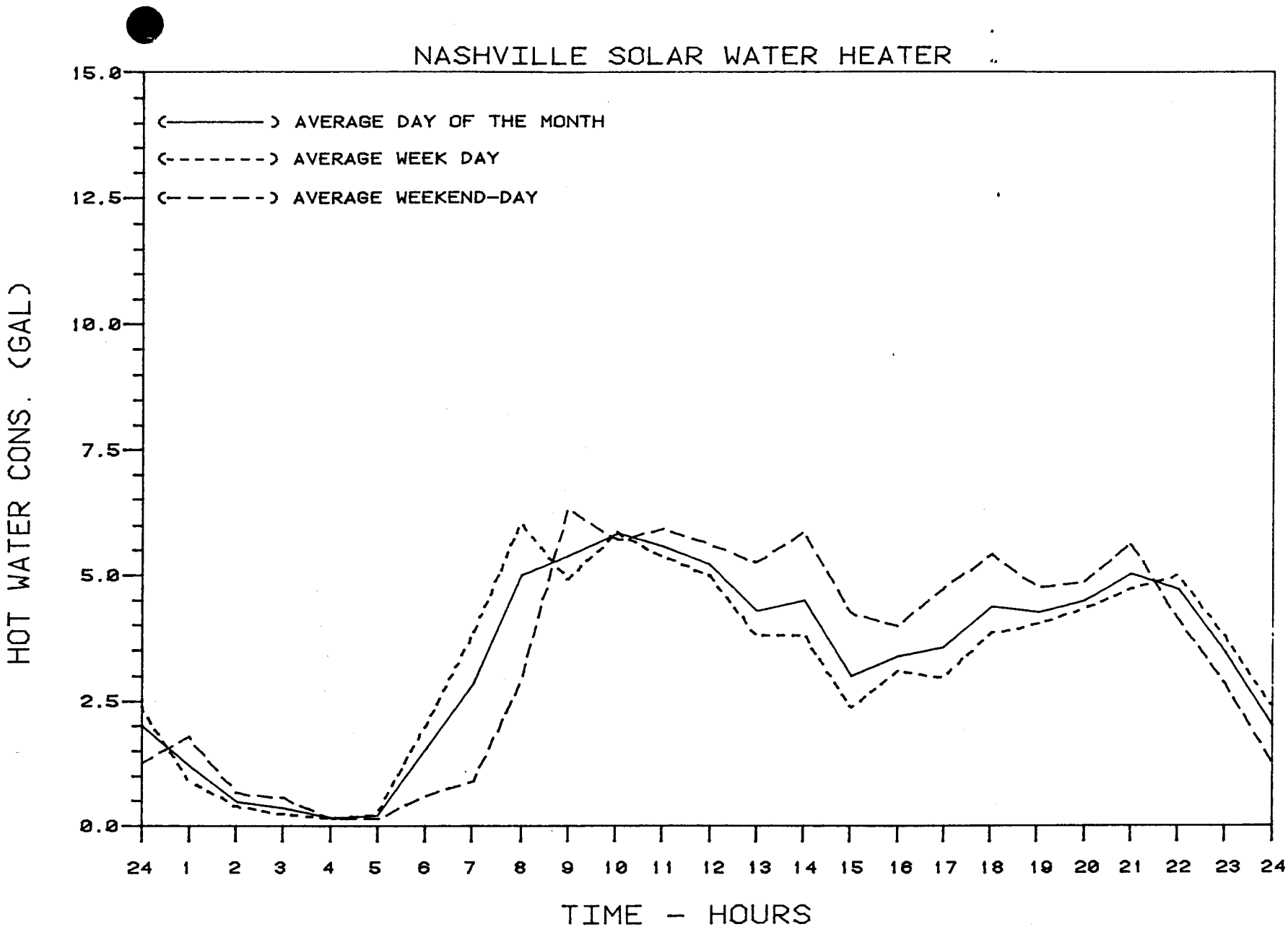

FIGURE 13 PROFILE OF AVERAGE HOT WATER CONSUMPTION FOR AVERAGE DAY OF THE MONTH, AVERAGE WEEKDAY, AND AVERAGE WEEKEND-DAY FOR AUGUST 1981

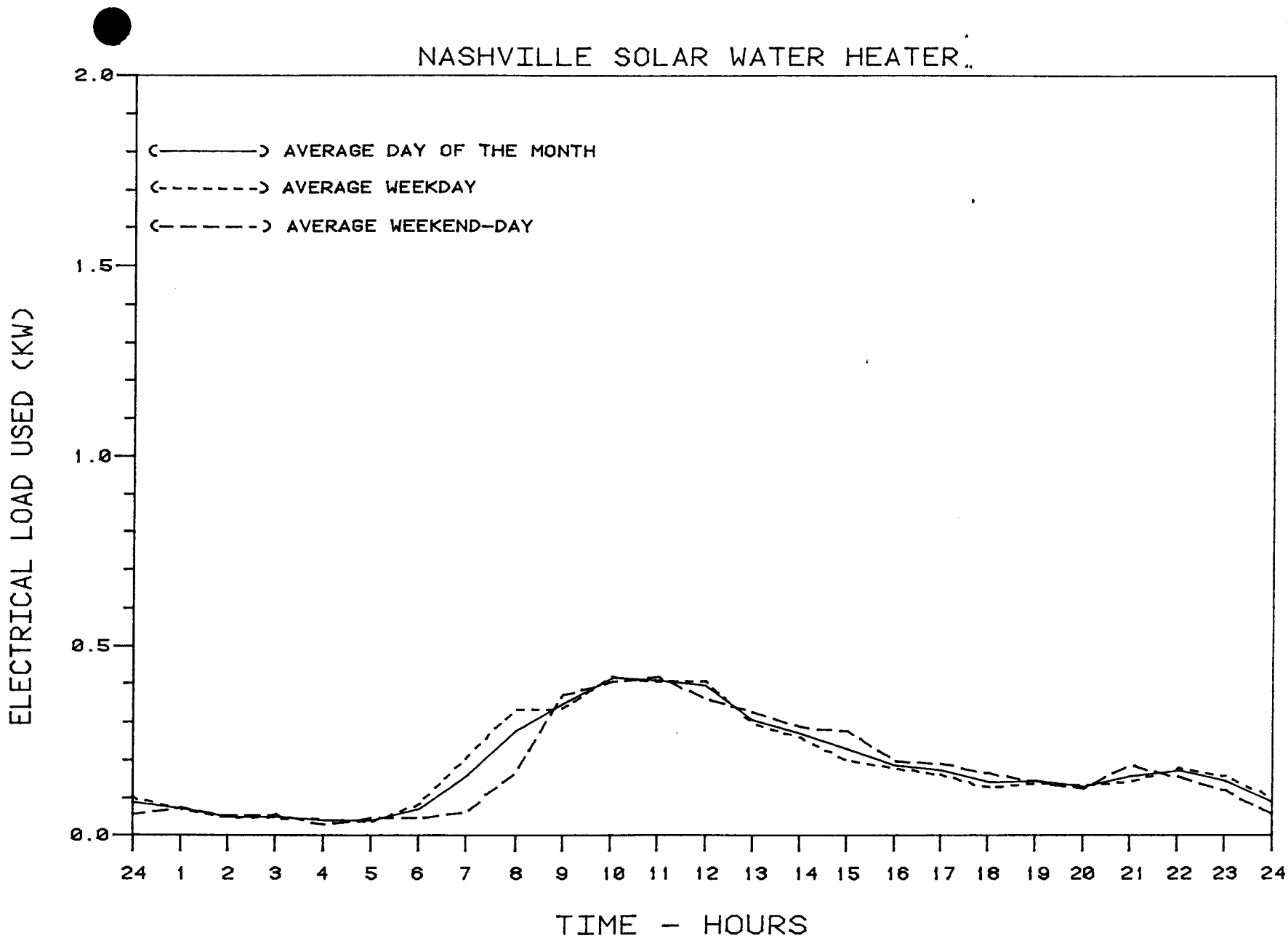

FIGURE 14 PROFILE OF AVERAGE ELECTRICAL LOAD USED FOR AVERAGE DAY OF THE MONTH. AVERAGE WEEKDAY. AND AVERAGE WEEKEND-DAY FOR AUGUST 1981

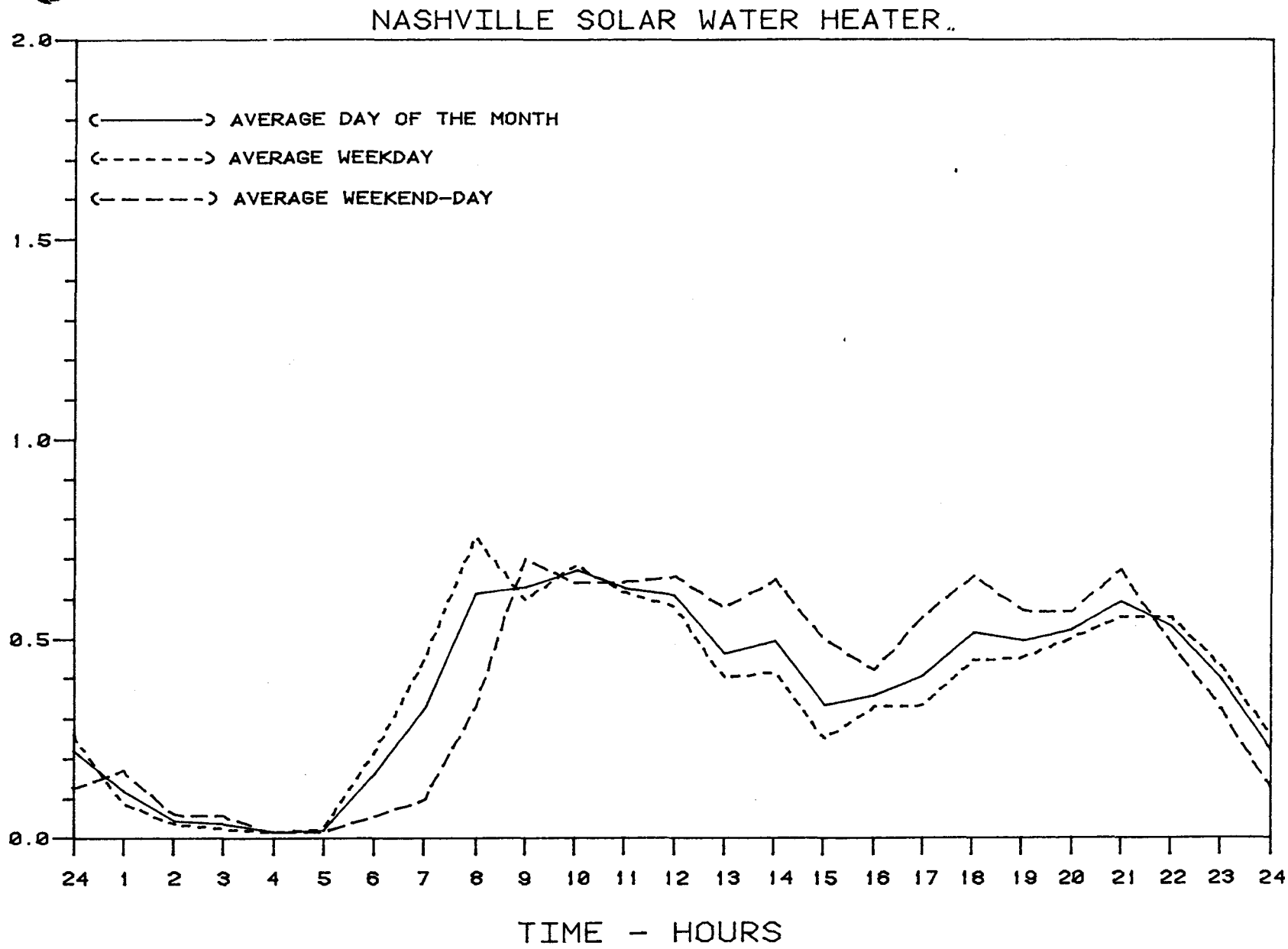

FIGURE 15 PROFILE OF AVERAGE TOTAL THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH. AVERAGE WEEKDAY. AND AVERAGE WEEKEND-DAY FOR AUGUST 1981

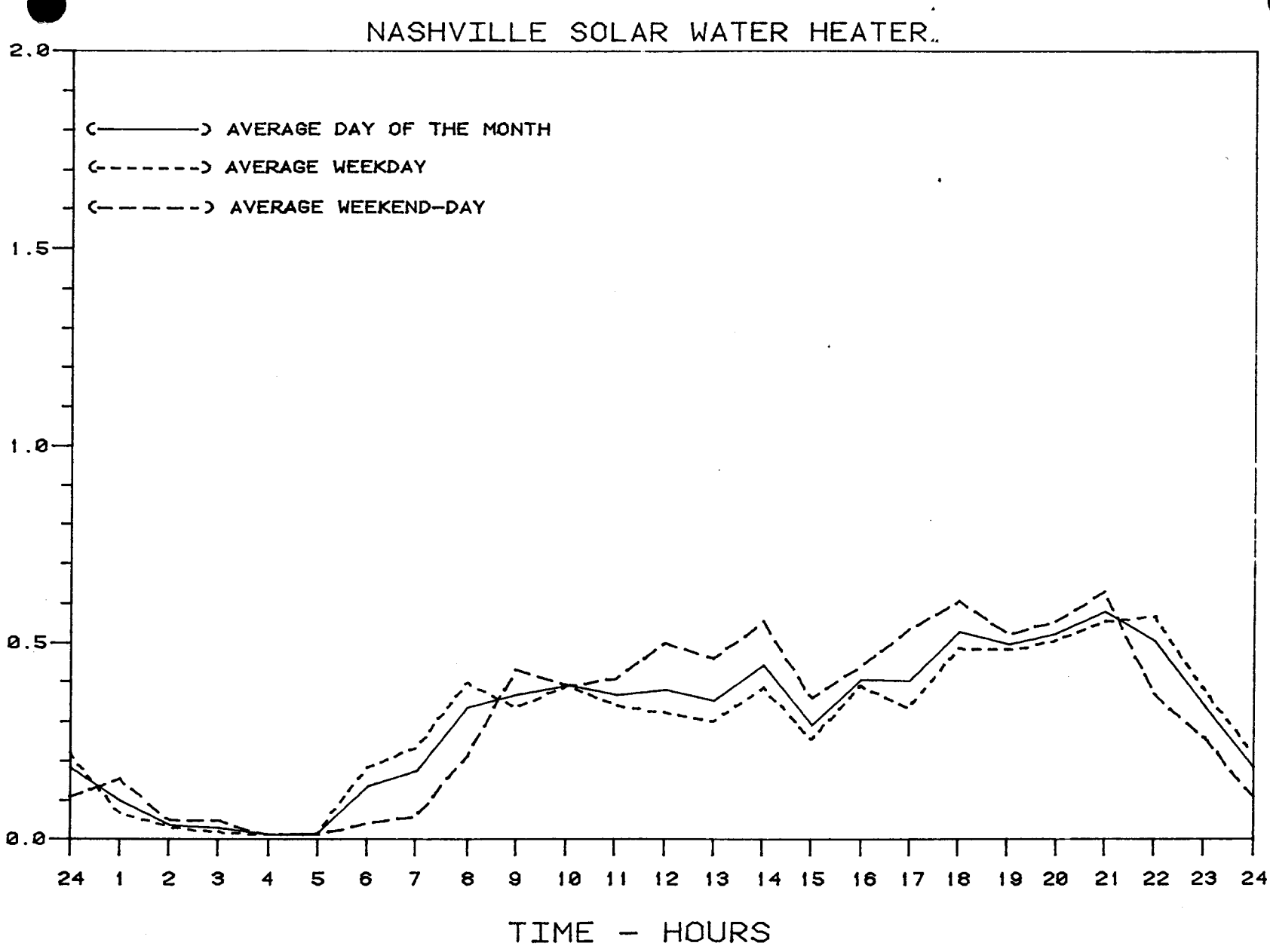

FIGURE 16 PROFILE OF AVERAGE SOLAR THERMAL LOAD SUPPLIED FOR AVERAGE DAY OF THE MONTH. AVERAGE WEEKDAY. AND AVERAGE WEEKEND-DAY FOR AUGUST 1981

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.100	0.118	0.069	1.203
2:00	0.036	0.043	0.050	0.467
3:00	0.026	0.033	0.047	0.322
4:00	0.011	0.015	0.038	0.148
5:00	0.013	0.021	0.038	0.207
6:00	0.139	0.161	0.071	1.524
7:00	0.176	0.333	0.158	2.827
8:00	0.342	0.623	0.275	5.020
9:00	0.367	0.633	0.344	5.372
10:00	0.395	0.673	0.412	5.786
11:00	0.363	0.623	0.407	5.498
12:00	0.383	0.616	0.393	5.221
13:00	0.347	0.460	0.300	4.204
14:00	0.442	0.497	0.265	4.469
15:00	0.284	0.330	0.223	2.923
16:00	0.404	0.360	0.185	3.366
17:00	0.390	0.401	0.169	3.471
18:00	0.530	0.519	0.138	4.374
19:00	0.498	0.495	0.137	4.261
20:00	0.527	0.526	0.124	4.503
21:00	0.585	0.594	0.155	5.016
22:00	0.492	0.525	0.165	4.619
23:00	0.339	0.398	0.142	3.450
24:00	0.186	0.219	0.085	2.017
TOTAL	7.374	9.218	4.391	80.269

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 80.269 GALLONS
AVERAGE ELECTRICAL LOAD USED = 4.391 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 9.218 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 7.374 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.30
AVERAGE DAILY THERMAL LOAD SAVED = 7.13 KWH

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.070	0.091	0.067	0.902
2:00	0.032	0.037	0.048	0.388
3:00	0.018	0.023	0.044	0.229
4:00	0.010	0.014	0.042	0.148
5:00	0.015	0.024	0.034	0.238
6:00	0.186	0.213	0.084	1.988
7:00	0.231	0.447	0.204	3.754
8:00	0.407	0.765	0.329	6.075
9:00	0.337	0.601	0.334	4.909
10:00	0.390	0.688	0.416	5.823
11:00	0.340	0.615	0.404	5.319
12:00	0.320	0.587	0.408	4.987
13:00	0.287	0.398	0.292	3.685
14:00	0.384	0.420	0.256	3.791
15:00	0.251	0.252	0.200	2.345
16:00	0.389	0.333	0.179	3.093
17:00	0.323	0.327	0.159	2.878
18:00	0.492	0.451	0.127	3.867
19:00	0.486	0.459	0.138	4.056
20:00	0.509	0.505	0.128	4.332
21:00	0.556	0.553	0.142	4.695
22:00	0.554	0.545	0.172	4.894
23:00	0.376	0.432	0.155	3.753
24:00	0.224	0.265	0.098	2.405
TOTAL	7.188	9.045	4.459	78.556

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 78.556 GALLONS
AVERAGE ELECTRICAL LOAD USED = 4.459 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 9.045 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 7.188 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.28
AVERAGE DAILY THERMAL LOAD SAVED = 6.85 KWH

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

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

TIME (HOUR)	QSOLAR (KWH)	QTOTAL (KWH)	QAUX (KWH)	GALLONS (GAL)
1:00	0.163	0.176	0.073	1.837
2:00	0.045	0.055	0.053	0.634
3:00	0.045	0.053	0.054	0.516
4:00	0.011	0.015	0.029	0.145
5:00	0.010	0.016	0.045	0.141
6:00	0.041	0.052	0.044	0.551
7:00	0.059	0.095	0.061	0.880
8:00	0.204	0.326	0.163	2.806
9:00	0.429	0.701	0.366	6.342
10:00	0.404	0.642	0.406	5.709
11:00	0.410	0.641	0.414	5.875
12:00	0.515	0.677	0.360	5.714
13:00	0.473	0.590	0.318	5.292
14:00	0.564	0.657	0.285	5.892
15:00	0.354	0.493	0.270	4.136
16:00	0.435	0.418	0.197	3.941
17:00	0.529	0.555	0.190	4.717
18:00	0.611	0.662	0.162	5.437
19:00	0.524	0.571	0.136	4.691
20:00	0.564	0.572	0.118	4.864
21:00	0.648	0.681	0.183	5.691
22:00	0.362	0.483	0.152	4.040
23:00	0.262	0.326	0.114	2.814
24:00	0.104	0.122	0.056	1.203
TOTAL	7.766	9.581	4.248	83.867

AVERAGE DAILY HOT WATER CONSUMPTION FOR THE GROUP = 83.867 GALLONS
AVERAGE ELECTRICAL LOAD USED = 4.248 KWH
AVERAGE DAILY TOTAL THERMAL LOAD SUPPLIED = 9.581 KWH
AVERAGE DAILY SOLAR THERMAL LOAD SUPPLIED = 7.766 KWH
AVERAGE DAILY SAVINGS FOR THE GROUP IN DOLLARS =$ 0.32
AVERAGE DAILY THERMAL LOAD SAVED = 7.73 KWH

TABLE 17 - SUMMARY OF DATA BY SITE FOR AUGUST 1981

Site No.	Mfg. No.	Family Size	No. of Days of Data	Q_{SOLAR} (kWh)	Q_{TOTAL} (kWh)	Q_{AUX} (kWh)	Water Consumption (Gal)	Total Energy Saved by System (kWh)	Total Savings ($)	Energy Multiplier (EM)	Solar System Savings Percentage %
1	18	4	31	181	200	108	1,843	142	5.90	1.85	56.7
2	5	2	21	197	173	39	1,774	177	7.34	4.38	81.7
3**	5	2	31	136	155	203	1,778	- 9	-0.39	0.76	-4.9
4	5	2	31	176	150	74	1,377	113	4.71	2.02	60.4
5	18	4	30	153	141	98	1,384	78	3.26	1.44	44.5
6	5	6	31	351	318	145	3,897	252	10.48	2.19	63.5
7**	16	4	31	106	235	236	2,282	120	4.99	1.21	33.7
8	16	4	25	61	110	100	757	38	1.57	1.10	27.4
9	2	3	31	N/A	125	25	823	131	5.44	4.94	83.8
10	5	3	31	300	376	119	2,733	351	14.60	3.15	74.6
11	5	4	11	108	118	32	1,576	116	4.81	3.73	78.6
12	11	2	31	248	298	81	2,648	292	12.12	3.70	78.3
13	2	4	24	N/A	303	124	2,089	254	10.55	2.44	67.1
14	16	4	27	318	648	366	4,580	444	18.47	1.77	54.8
15	16	3	31	288	461	199	4,166	377	15.66	2.31	65.4
16	16	1	31	73	61	39	655	37	1.53	1.55	48.3
17	2	7	31	N/A	434	247	2,867	296	12.29	1.76	54.4
18	11	6	15	119	177	100	1,573	121	5.02	1.76	54.7
19	5	3	21	213	194	37	1,528	206	8.57	5.25	84.8
20	8	3	24	274	303	53	3,660	326	13.55	5.75	86.1
21	not installed										
22	11	4	5	38	51	22	502	42	1.74	2.31	65.4
23	2	2	20	N/A	92	32	670	82	3.41	2.82	71.6
24	5	3	5	47	35	19	435	25	1.05	1.87	57.3

**denotes differential controller malfunction.

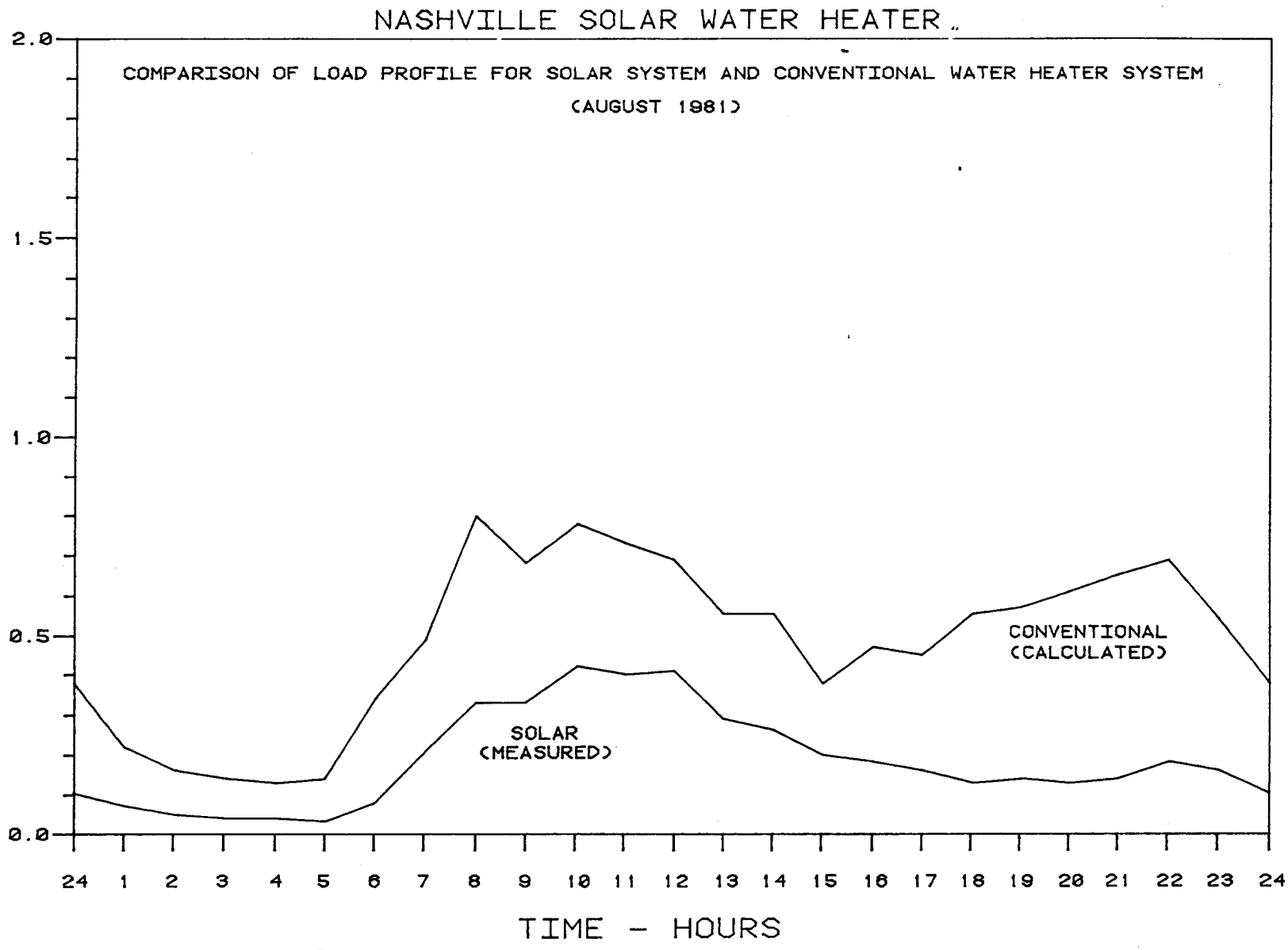

FIGURE 17 AVERAGE WEEKDAY PROFILE OF ELECTRICAL LOAD FOR AVERAGE SOLAR SYSTEM AND CONVENTIONAL WATER HEATER SYSTEM FOR AUGUST 1981

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 AUGUST 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	0.07	0.90	0.22
2	0.05	0.38	0.16
3	0.04	0.22	0.14
4	0.04	0.15	0.13
5	0.03	0.24	0.14
6	0.08	2.01	0.34
7	0.21	3.32	0.49
8	0.33	6.02	0.80
9	0.33	4.91	0.68
10	0.42	5.84	0.78
11*	0.40	5.37	0.73
12*	0.41	4.98	0.69
13*	0.29	3.77	0.55
14*	0.26	3.80	0.55
15*	0.20	2.36	0.38
16*	0.18	3.08	0.47
17*	0.16	2.94	0.45
18*	0.13	3.84	0.55
19*	0.14	4.02	0.57
20*	0.13	4.32	0.61
21*	0.14	4.71	0.65
22*	0.18	4.99	0.69
23	0.16	3.76	0.54
24	0.10	2.36	0.38
Total	4.48	78.29	11.69
On Peak Totals	2.62		6.89

*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)	Energy Multiplier (EM)	Solar System Savings Percent (%)
April [2]	8	3.6	7.3	11.1	6.7	83	7.1	0.30	1.66	50.0
May [2]	10	3.7	6.3	10.3	7.0	78	5.9	0.25	1.56	46.0
June	17	3.8	7.3	8.6	3.7	66	7.0	0.29	3.23	65.9
July	19	3.8	6.6	8.4	3.6	69	6.8	0.28	3.09	60.1
August	23	3.7	7.1	9.0	4.4	79	7.0	0.29	2.61	60.4

TABLE 20. REASONS WHY SOME DATA WERE NOT USED

SITE NUMBER	DURATION OF OCCURANCE	CAUSE
2	6/12-6/14	Many hours of too high kWh values.
	6/24-6/25	Many hours of too high Q_{TOTAL}, GAL, and kWh values.
	7/24-8/07	Water useage reading zeros.
4	6/5-6/6	Many hours of too high GAL and kWh values.
5	6/22-7/8	Phone line not answering. South Central Bell repaired phone line.
6	6/1-7/28	GAL reading zeros.
8	6/11-6/12	Many hours too high Q_{SOLAR} and Q_{TOTAL} values.
	8/6/-8/7	Many hours too high Q_{SOLAR} and kWh values.
	8/16-8/17	Many hours too high Q_{TOTAL} and GAL values.
9	6/8-6/17	Phone line not answering.
10	6/23-6/24	Too many hours. Too high kWh values.
11	6/6-6/13	kWh reading zeros.
	7/3-/7/23	kWh reading zeros.
	7/28-8/5	kWh reading zeros.
	8/13-8/18	kWh reading zeros.
13	6/16-6/25	Robinton not answering.
	6/27-7/30	Q_{SOLAR} and Q_{TOTAL} reading zeros.
	8/22-8/29	Faulty Q_{SOLAR}, Q_{TOTAL}, and water useage readings.
14	7/24-7/31	Q_{SOLAR} reading too high.
18	7/24-8/7	Q_{SOLAR} and Q_{TOTAL} reading zeros.
	8/23-8/31	Q_{SOLAR} reading zeros.
19	8/18-8/27	Phone not answering.