

**Monitoring and Performance Evaluation
of the Combined Photovoltaic and
Thermal Solar Collector System**

Final Report

**Final Report: Data Acquisition System for Montana State University
Bozeman, Montana.**

**Period of Observation: April 1st – August 31st
Installer: Solar Design Associates
Engineer: Craig Munger**

This report contains the compiled results of the data acquisition system that was installed for Montana State University to monitor the parameters described herein of the two combined photovoltaic and solar thermal panels that exist on the roof of the Safety and Risk Management Building in the Advanced Technology Park in Bozeman Montana. The report documentation is divided into six sections and is as follows:

1. Introduction
2. Methods
3. Summary
4. Appendix A: Data Summaries
5. Appendix B: Relevant Equations
6. References

For details on the equipment and the data acquisition system installation please refer to the Installation Report dated April 16th 2001. Questions or concerns regarding the information contained herein can be directed to:

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1. Introduction

The purpose of the work described herein is to quantify several important operating parameters of the combined photovoltaic / thermal collector (PV/T) as fielded at the Advanced Technology Park in Bozeman, Montana. The parameters that are of main interest are, the effect of temperature on the electrical output of the system and the average operating temperature of the collector.

Quantifying the effect of temperature on electrical output will allow designers who wish to utilize this collector in future installations to make the proper selection of balance of system components by matching the output of the collector to either a DC to AC inverter or DC load. The operating temperature of the system is of particular importance to determine the feasibility and durability of the materials that are selected for the construction of this unique collector type. Finally, as more installations of the PV/T system are considered as solutions to meet consumer demand, the overall useful output of the PV/T will provide the designer and consumer a means of comparing the benefits of the combined collector with other single output collectors (electrical or thermal).

Two PV/T collectors manufactured by Solar Design Associates, Inc. of Harvard, Massachusetts, have been installed on the rooftop of the Safety and Risk Management Building located at the Advanced Technology Park in Bozeman, Montana. They supply electrical power by the use of amorphous silicon photovoltaic cells and thermal energy by means of a re-circulating propylene glycol/water mixture system. A heat exchanger preheats the domestic hot water for the building using the re-circulating propylene glycol/water as the heat source. The DC power produced by the photovoltaic cells is coupled to the building energy system by means of a Trace Engineering Sun-Tie 1500W DC to AC inverter and an ACME buck/boost transformer to match the voltage output of the inverter (240 Vac) to that used in the building (208 Vac).

2. Methods

The Data Acquisition System consists of an Agilent HP34970A switch unit with one HP34901A 20-Channel multiplexer. The Channel Assignments and labels are detailed in the Installation Report. The unit was configured to sample all of the parameters once every minute for every hour of the entire data collection period. This data collection period took place between the months of April 2001 through August 2001. In order to facilitate the data transfer process the data logging was stopped as frequently as twice a week in order to export the logged data to a spreadsheet file. This data exporting typically lasted a few minutes and the data logger down time should have a negligible effect on the overall data collected.

The spreadsheet files containing several days worth of data logged every minute were first separated into individual files containing just the data for each minute of one day. This process also filtered the data utilizing the accuracy defined by the manufacturer to exclude any abnormal values and also performed several conversions to convert degrees Fahrenheit to degrees Celsius and gallons per minute to liters per minute in order to conform with the report requirements. This daily file was then compressed into another daily file, which contains an average value for each hour of the day. This hourly data was then used to obtain the daily averages and totals that are presented in the data summary spreadsheets in Appendix A. The file separation and data averaging described above was accomplished utilizing National Instruments Labview® software.

In accordance with the project requirements the following parameters were measured:

1. Ambient temperature.
2. Irradiance in the plane of the array.
3. Collector plate temperature.
4. Fluid temperature at the inlet of the solar collector.
5. Fluid temperature at the outlet of the solar collector.
6. Flow rate of the fluid flowing through the collector.
7. Temperature of the water coming into the building.
8. Temperature of the hot water going to the building loads.
9. Flow rate of the hot water going out to the building loads.
10. DC current output of the solar collectors.
11. DC voltage of the solar collectors.
12. AC power output of the DC/AC inverter.
13. AC power input to the supplemental electric water-heating element.

Utilizing the above measured parameters the following parameters were calculated utilizing the equations in Appendix B:

1. Energy delivered to the preheat tank by the solar collectors was calculated utilizing measured parameters 4,5 and 6 and Equation 3. The solar loop contains a mixture of water and DowFrost® propylene glycol. From the specific gravity reading of 1.0185 taken at ~26.7°C the percentage of DowFrost® in solution was calculated to be 20%. From the manufacturers tables the heat capacity of the solution was calculated to be 3.99kJ/kg°C at 26.7°C. This value was adjusted for the various operating temperatures of the system.
2. The energy consumed by the domestic hot water load was calculated in a similar manner utilizing measured parameters 7, 8, and 9, Equation 3 and the standard heat capacity of water (4.19kJ/kgC at 20°C).
3. The DC electrical power output of the panels was calculated with measured parameters 10 and 11 and Equation 9.
4. The estimated inverter output power was calculated using measured parameters 2 and 3, Equation 10, and the assumptions for the remaining parameters shown in Appendix B. This equation was modified to take into account the fact that additional photovoltaic panels were added to the system on August 20th, 2001.*
5. The solar energy input to the collectors was calculated utilizing measured parameter 2 and Equation 4 and supporting Equations 5,6, and 7 as shown in Appendix B. The calculation for this value was also modified in a similar manner to the one above to account for the changes in system size.
6. The fraction of the building demand for hot water that was met by the operation of the solar panels, (thermal plus electrical output of the inverter) was calculated and is shown for each week and month of system operation as well as for the entire data collection period.

* The estimated inverter output was calculated with the assumption that all of the photovoltaic modules that were added on August 20th would operate at the same temperature of the photovoltaics in the combined PV/T collector. This was done in order to show the comparison of actual output of the modules in free air to the expected output of the modules at elevated temperatures.

3. Summary

The system performance parameters are summarized in the data spreadsheets in Appendix A. For the first four months of the data collection period the combined solar energy input (electrical plus thermal) was able to supply an average of 35% of the building demand for domestic hot water use. The addition of a substantial quantity photovoltaic panels in the last two weeks of the data collection period, pushed the overall average percentage of DHW load supplied to 46%.

The average values shown in the data summary spreadsheets may appear lower than would be expected, however it should be noted that the values are averaged over the entire day and include both maximum and minimum values for the day. A good measure of the daily performance of the various aspects of the system is contained within the integrated totals for each day, week, month, and over the entire data collection period.

The overall electrical efficiency shown in the data summaries includes the loss of insolation through the thermal collector glazing. In general the photovoltaic system appears to be operating at about 40% of the estimated capacity. There are several reasons for this. The average operating voltage of the combined collectors was typically less than the minimal operating voltage required by the inverter. This also means that it was outside of the maximum power tracking voltage range of the inverter. Both of these results are due to the elevated temperatures of the combined collector (temperatures as high as 111°C were observed). The collectors are capable of delivering a finite amount of electrical power. At elevated temperatures the current increases and the voltage decreases. For this reason it can be assumed that the inverter fluctuated more frequently than anticipated between the open circuit voltage with zero current flowing and minimal operating voltage. From the last two weeks worth of data it can be seen that the inverter operates at a much higher efficiency with the addition of more DC generating capability. In particular the additional panels are operating at a much lower temperature than the PV/T panels and therefore provide a more consistent higher voltage that holds the entire photovoltaic system above the minimum operating voltage of the inverter and within the maximum power tracking range of the inverter.

There were periods during the data collection period when the power was observed to be negative. These were generally during periods of low sun when the inverter was most likely fluctuating between on and off states. There is not substantial data on the ability of the inverter to maintain a high power factor when it is operating at a substantially lower power than its nameplate rating. Before the addition of more photovoltaic panels the 1500W inverter was operating at an average value less than 100W. The negative power readings observed are most likely due to the reactive power draw of the buck/boost transformer when it is reconnected as a load. It is suggested that future studies of this system include a Volt-Ampere Reactive transducer in order to determine more accurately the behavior of the inverter during periods of low power.

As expected the overall thermal efficiency of the system shows a decline as the average ambient temperatures increase. However, after reviewing the summarized data it appears that the differential control on the circulating pump may not be operating properly. This is most notable for days on which there was no recorded useful thermal energy gain by the collector. A review of the daily data logged once a minute clearly shows a large enough temperature differential between the outlet temperature of the heat exchanger and the outlet fluid temperature of the solar collector for the circulating pump to be on, yet no flow was recorded during this time. The temperature sensors, and controller of the circulating pump should be checked to verify proper operation as well as compliance with the pump manufacturer's recommendations. It can be assumed that the solar thermal energy gained will be improved when the pump is operating properly.

The data acquisition system checks for fluid flow once every minute. It is assumed that when flow is recorded it occurs for at least one minute. One suggestion for more accuracy in the fluid

flow measurements is to increase the sampling frequency from once a minute to at least once per second or another option is to add an accumulator module to the Agilent unit to measure total volume of fluid flow.

In general the Agilent Data Acquisition Unit performed as expected with the exception of its ability to perform and record computations on the measured channels while logging data. The unit was initially set-up to compute the DC power output while simultaneously taken measurements on all channels. It was found that this computation disrupted the logging of data for about 10 minutes every three hours but this disruption would vary between data downloads. The computational function was turned off and all computations were done after the logged data was downloaded to the spreadsheet file. According to the manufacturer this abnormal functionality can be remedied with an updated version of the BenchLink Data Logger Software or alternatively with some of the advanced software products available for the data acquisition unit.

Appendix A: Data Summaries

Table 1: Daily Average Values for April

Date	Avg. Ambient Temp. (C)	Avg. Irradiance (kW/sq.m)	Total Irradiation (kWh/sq.m)	Avg. Panel Temp (C)	Solar Panel Fluid Inlet Temp (C)	Solar Panel Fluid Outlet Temp (C)	Avg. Panel Flow Rate (L/m)	Avg. Rate of Energy Transfer by Panels (kW)	Total Panel Energy Transfer (kWh)	Cold Water Supply Temp. (C)	Water Heater Outlet Temp (C)	Avg. DHW Flow Rate (L/m)	Avg. Rate Energy Transfer to DHW (kW)	Total Energy Transfer to Hot Water (kWh)
1-Apr	5.02	269.09	5.11	21.82	26.24	27.63	0.46	0.32	1.28	19.31	27.76	0.44	0.29	1.46
2-Apr	3.95	270.15	5.94	20.47	27.24	29.39	0.67	0.49	3.44	18.22	28.84	0.57	0.82	5.76
3-Apr	0.60	429.41	6.87	21.24	25.33	25.68	0.36	0.43	3.04	13.58	24.70	4.34	4.45	48.91
4-Apr	-1.44	201.45	4.43	15.02	21.81	17.86	0.42	0.60	1.20	10.88	24.71	3.60	2.29	29.71
5-Apr	3.69	408.29	7.76	25.56	24.27	25.51	0.55	0.76	4.54	16.86	31.00	0.40	0.68	4.09
6-Apr	5.17	406.59	6.51	23.77	24.42	24.86	0.31	0.40	1.59	17.65	31.02	0.23	0.33	1.63
7-Apr	5.54	282.69	4.81	20.42	23.85	23.51	0.19	0.18	0.91	21.06	27.55	0.00	0.00	0.00
8-Apr	0.41	64.04	1.22	4.09	23.06	21.61	0.00	0.00	0.00	21.54	29.09	0.00	0.00	0.00
9-Apr	-0.05	142.38	2.56	10.73	22.40	20.97	0.00	0.00	0.00	17.98	30.56	0.18	0.25	1.50
10-Apr	1.41	198.67	3.78	15.66	22.07	21.53	0.18	0.08	0.17	17.18	30.18	0.16	0.22	1.10
11-Apr	1.02	311.41	5.61	18.19	21.08	18.41	0.18	0.21	0.21	17.48	29.72	0.18	0.31	0.62
12-Apr	-1.51	107.73	1.83	5.01	20.79	15.72	0.00	0.00	0.00	18.89	30.67	0.23	0.32	1.89
13-Apr	0.75	273.55	5.20	16.22	22.94	18.76	0.12	0.00	0.00	19.02	29.58	0.18	0.23	0.45
14-Apr	-0.07	246.16	5.66	17.51	21.04	17.72	0.00	0.00	0.00	20.33	26.65	0.00	0.00	0.00
15-Apr	1.79	508.20	7.62	22.47	25.34	26.59	0.52	0.55	4.41	20.64	27.10	0.00	0.00	0.00
16-Apr	0.80	503.76	7.56	23.16	21.78	20.74	0.14	0.21	0.63	16.78	30.35	0.16	0.27	0.80
17-Apr	8.70	412.41	6.19	26.41	22.74	23.49	0.26	0.40	2.79	17.34	30.75	0.14	0.21	0.84
18-Apr	7.84	430.87	5.60	29.11	21.13	24.48	0.21	0.25	1.72	16.40	28.47	0.14	0.23	0.70
19-Apr	8.70	412.41	6.19	26.41	22.74	23.49	0.26	0.40	2.79	17.34	30.75	0.14	0.21	0.84
20-Apr	0.67	194.35	2.53	15.89	20.21	20.26	0.00	0.00	0.00	15.36	34.18	0.17	0.30	1.78
21-Apr	-0.63	217.48	4.79	14.33	20.10	19.55	0.12	0.00	0.00	19.56	31.95	0.12	0.25	1.02
22-Apr	2.88	334.94	6.03	22.27	22.27	23.31	0.18	0.26	0.78	19.96	31.41	0.06	0.04	0.04
23-Apr	5.99	134.76	2.97	14.77	20.05	19.82	0.24	0.26	0.26	17.12	33.59	0.28	0.46	1.38
24-Apr	9.61	356.88	7.85	34.24	22.03	26.54	0.28	0.26	1.04	17.00	34.52	0.47	1.13	5.62
25-Apr	12.05	414.18	7.87	34.84	22.18	26.76	0.29	0.55	2.74	17.18	35.87	0.63	1.53	13.80
26-Apr	14.03	429.84	7.74	38.25	23.39	28.39	0.24	0.35	2.45	17.57	35.86	0.20	0.36	3.55
27-Apr	13.82	315.61	5.37	31.60	25.49	27.87	0.32	0.37	1.48	17.62	35.94	0.24	0.41	4.45
28-Apr	15.33	277.32	5.55	29.87	26.45	27.25	0.18	0.15	0.76	21.15	32.92	0.06	0.05	0.09
29-Apr	7.38	261.68	5.50	24.74	23.38	24.33	0.20	0.20	0.60	19.79	31.43	0.00	0.00	0.00
30-Apr	10.09	109.99	2.42	17.51	20.35	20.83	0.12	0.00	0.00	16.91	33.13	0.17	0.24	0.96

Table 1: Daily Average Values for April

Date	Average Water Heater Power (kW)	Total Water Heater Energy Consumed (kWh)	Avg. DC Current (A)	Avg. DC Voltage (V)	Avg. DC Power (W)	Total DC Energy (kWh)	Avg. Inverter Output (W)	Total Inverter Energy (kWh)	Est. Inverter Avg. Ouput (W)	Total Est. Inverter Ouput (kWh)	Avg. Solar Energy Input (kW)	Total Solar Energy Input (kWh)	Avg. Overall Electrical Efficiency	Avg. Overall Thermal Efficiency
1-Apr	0.13	1.30	1.55	37.90	81.44	1.22	32.47	0.46	56.70	1.08	0.85	16.22	1.73%	7.86%
2-Apr	0.16	1.65	2.00	30.75	85.62	1.28	30.09	0.48	56.69	1.25	0.86	18.86	1.58%	18.23%
3-Apr	2.43	36.38	2.37	29.51	92.27	1.38	35.66	0.54	89.25	1.43	1.36	21.80	1.52%	13.94%
4-Apr	2.60	44.15	1.29	34.82	60.86	0.91	15.93	0.24	43.24	0.95	0.64	14.06	1.05%	8.54%
5-Apr	0.43	5.11	2.30	34.24	117.39	1.76	48.14	0.72	84.03	1.60	1.30	24.62	1.81%	18.44%
6-Apr	0.22	1.99	1.91	38.72	103.24	1.55	39.79	0.60	83.92	1.34	1.29	20.64	1.79%	7.71%
7-Apr	0.11	0.88	1.56	31.84	76.82	1.08	23.77	0.33	59.65	1.01	0.90	15.25	1.35%	5.97%
8-Apr	0.11	1.00	0.33	26.07	10.66	0.15	1.79	0.02	14.64	0.28	0.20	3.86	0.34%	NC
9-Apr	0.19	2.26	0.68	32.99	33.92	0.51	3.75	0.05	31.38	0.57	0.45	8.13	0.40%	NC
10-Apr	0.26	2.61	1.17	34.69	55.31	0.83	10.59	0.17	42.88	0.82	0.63	11.98	0.87%	1.39%
11-Apr	1.27	17.82	1.79	31.80	78.25	1.17	21.88	0.35	65.97	1.19	0.99	17.79	1.22%	1.20%
12-Apr	0.11	1.16	0.32	46.28	19.21	0.29	1.81	0.02	24.43	0.42	0.34	5.81	0.21%	NC
13-Apr	0.16	1.43	1.68	26.20	66.81	1.00	25.78	0.34	57.40	1.09	0.87	16.49	1.25%	NC
14-Apr	0.16	1.59	1.69	36.32	79.29	1.19	24.71	0.37	52.64	1.21	0.78	17.97	1.28%	NC
15-Apr	0.10	1.03	2.55	29.55	102.97	1.55	42.48	0.60	105.46	1.58	1.61	24.19	1.52%	18.22%
16-Apr	0.71	9.99	2.58	30.52	102.58	1.54	40.28	0.60	104.19	1.56	1.60	23.98	1.56%	2.64%
17-Apr	0.66	7.22	2.09	29.57	90.34	1.36	33.35	0.50	84.91	1.27	1.31	19.63	1.57%	14.21%
18-Apr	0.19	1.56	2.94	32.42	119.76	1.20	40.41	0.49	86.87	1.13	1.37	17.78	1.69%	9.68%
19-Apr	0.66	7.22	2.09	29.57	90.34	1.36	33.35	0.50	84.91	1.27	1.31	19.63	1.57%	14.21%
20-Apr	0.78	3.12	1.09	28.69	54.01	0.59	56.75	0.23	40.66	0.53	0.62	8.02	1.75%	NC
21-Apr	0.92	1.84	1.52	36.07	70.15	1.05	27.00	0.30	46.85	1.03	0.69	15.18	1.21%	NC
22-Apr	0.52	1.57	1.52	47.63	90.58	1.36	45.12	0.50	69.91	1.26	1.06	19.13	1.60%	4.05%
23-Apr	0.79	2.37	0.75	39.46	40.80	0.61	10.49	0.12	29.46	0.65	0.43	9.41	0.75%	2.81%
24-Apr	0.97	4.87	2.72	33.10	107.43	1.61	59.43	0.65	71.24	1.57	1.13	24.92	1.62%	4.16%
25-Apr	1.24	9.89	2.74	31.14	107.78	1.62	58.61	0.65	82.39	1.57	1.31	24.97	1.60%	10.97%
26-Apr	0.50	2.50	2.63	33.84	110.05	1.65	59.66	0.66	84.60	1.52	1.36	24.55	1.65%	9.99%
27-Apr	0.54	2.71	1.76	35.56	81.43	1.22	31.99	0.38	64.18	1.09	1.00	17.03	1.39%	8.70%
28-Apr	0.82	0.82	1.51	44.50	83.14	1.25	34.53	0.41	57.45	1.15	0.88	17.60	1.45%	4.32%
29-Apr	0.91	1.82	1.74	30.32	79.65	1.20	31.87	0.38	54.61	1.15	0.83	17.44	1.35%	3.46%
30-Apr	0.78	1.57	0.53	43.89	29.46	0.44	3.18	0.03	24.06	0.53	0.35	7.68	0.23%	NC
Average												1.30%	8.67%	

Table 2: Daily Average Values for May

Date	Avg. Ambient Temp. (C)	Avg. Irradiance (kW/sq.m)	Total Irradiation (kWh/sq.m)	Avg. Panel Temp (C)	Solar Panel Fluid Inlet Temp (C)	Solar Panel Fluid Outlet Temp (C)	Avg. Panel Flow Rate (L/m)	Avg. Rate of Energy Transfer by Panels (kW)	Total Panel Energy Transfer (kWh)	Cold Water Supply Temp. (C)	Water Heater Outlet Temp (C)	Avg. DHW Flow Rate (L/m)	Avg. Rate Energy Transfer to DHW (kW)	Total Energy Transfer to Hot Water (kWh)
1-May	3.36	159.33	3.51	13.41	20.91	20.67	0.12	0.00	0.00	17.93	34.55	0.20	0.33	2.00
2-May	1.95	272.47	6.27	21.90	27.27	27.64	0.25	0.37	2.24	19.60	35.60	0.15	0.23	0.94
3-May	3.89	510.43	8.17	29.93	24.80	28.74	0.22	0.29	1.46	18.55	34.89	0.49	0.93	6.52
4-May	8.74	466.83	7.94	34.61	25.02	28.07	0.19	0.35	1.39	18.79	33.93	0.38	0.53	4.23
5-May	8.94	245.47	4.42	21.61	23.65	22.77	0.24	0.33	0.33	20.05	31.22	0.06	0.03	0.03
6-May	3.90	417.81	7.94	26.84	23.96	24.72	0.20	0.25	0.75	20.69	31.48	0.06	0.04	0.11
7-May	8.31	435.42	7.84	31.61	23.15	26.09	0.18	0.22	0.65	18.02	34.74	0.55	1.23	7.38
8-May	14.04	261.49	5.49	29.84	25.62	24.49	0.22	0.19	0.96	16.64	35.63	0.28	0.54	3.25
9-May	11.37	266.92	5.34	28.95	23.98	25.73	0.26	0.43	1.73	17.11	35.94	0.32	0.60	4.23
10-May	9.16	392.90	7.47	33.32	24.22	26.74	0.20	0.28	1.65	17.51	36.45	0.25	0.51	4.04
11-May	12.28	386.29	6.57	33.62	24.73	26.74	0.17	0.22	0.89	18.66	38.29	0.34	0.54	2.71
12-May	16.96	358.25	6.81	38.49	26.26	29.37	0.20	0.22	0.87	22.69	37.14	0.06	0.05	0.16
13-May	19.28	255.32	5.36	35.59	28.01	29.52	0.23	0.23	0.69	22.21	37.50	0.14	0.13	0.53
14-May	16.62	291.12	5.82	32.28	23.72	24.80	0.20	0.30	1.22	17.08	34.54	2.78	3.42	34.21
15-May	11.04	181.51	3.09	20.30	20.94	17.71	0.21	0.19	0.38	17.17	38.56	0.47	0.96	8.64
16-May	8.44	236.90	4.98	21.20	21.57	19.17	0.17	0.17	0.67	17.11	38.11	0.14	0.24	0.97
17-May	8.79	450.90	7.67	33.72	21.06	24.40	0.14	0.24	0.95	16.66	38.83	0.29	0.56	3.38
18-May	11.26	263.95	5.54	27.71	23.14	22.97	0.23	0.44	1.74	17.96	38.65	0.25	0.47	2.83
19-May	11.21	319.55	6.07	28.39	24.21	22.77	0.21	0.30	0.89	19.53	36.22	0.00	0.00	0.00
20-May	6.87	419.18	6.71	25.78	22.02	20.99	0.08	0.14	0.41	18.96	35.57	0.11	0.11	0.68
21-May	7.95	442.29	7.52	28.58	22.25	22.26	0.08	0.12	0.46	16.16	38.76	0.30	0.61	6.74
22-May	14.00	412.63	7.84	37.35	23.20	26.66	0.20	0.29	1.47	18.73	38.73	0.26	0.47	1.88
23-May	16.83	433.74	7.81	40.81	24.95	28.80	0.17	0.26	1.02	17.96	38.94	0.39	0.74	5.20
24-May	19.21	442.62	7.52	42.93	25.87	29.38	0.19	0.21	1.26	19.13	39.43	0.26	0.55	2.76
25-May	16.68	234.47	4.22	30.44	26.23	26.60	0.20	0.22	0.66	19.57	38.44	0.27	0.46	1.82
26-May	15.89	303.48	6.37	36.99	25.45	28.05	0.20	0.18	0.90	22.87	36.60	0.00	0.00	0.00
27-May	14.81	278.82	4.74	29.40	25.59	25.83	0.17	0.20	0.78	20.67	36.15	0.14	0.24	0.71
28-May	13.73	259.66	4.93	29.17	25.98	26.23	0.11	0.13	0.75	20.34	36.35	0.24	0.28	1.41
29-May	11.15	245.50	5.16	25.71	22.67	23.14	0.39	0.39	0.78	17.51	37.67	0.36	0.63	3.78
30-May	10.00	304.82	6.71	32.27	24.41	26.85	0.14	0.20	0.79	17.97	38.51	0.17	0.34	1.69
31-May	13.73	444.33	7.55	36.44	25.12	27.98	0.17	0.23	1.17	18.25	38.80	0.32	0.52	2.08

Table 2: Daily Average Values for May

Date	Average Water Heater Power (kW)	Total Water Heater Energy Consumed (kWh)	Avg. DC Current (A)	Avg. DC Voltage (V)	Avg. DC Power (W)	Total DC Energy (kWh)	Avg. Inverter Output (W)	Total Inverter Energy (kWh)	Est. Inverter Avg. Ouput (W)	Total Est. Inverter Ouput (kWh)	Avg. Solar Energy Input (kW)	Total Solar Energy Input (kWh)	Avg. Overall Electrical Efficiency	Avg. Overall Thermal Efficiency
1-May	0.57	2.26	0.92	40.49	51.63	0.78	17.14	0.17	34.85	0.77	0.51	11.12	0.95%	
2-May	0.51	2.03	1.79	37.55	95.01	1.43	48.30	0.53	56.68	1.30	0.87	19.89	1.65%	11.24%
3-May	0.54	2.14	2.74	34.30	101.32	1.62	60.01	0.66	102.03	1.63	1.62	25.92	1.57%	5.64%
4-May	0.38	1.91	2.43	36.98	104.79	1.68	54.99	0.66	92.29	1.57	1.48	25.18	1.62%	5.53%
5-May	0.50	1.50	1.14	38.50	65.02	1.04	33.49	0.34	51.41	0.93	0.78	14.02	1.48%	2.32%
6-May	0.85	1.70	2.27	36.56	108.15	1.73	55.35	0.66	85.16	1.62	1.33	25.19	1.63%	2.98%
7-May	0.77	4.59	2.50	31.02	99.54	1.59	55.21	0.61	86.97	1.57	1.38	24.87	1.51%	2.60%
8-May	0.73	2.91	1.71	33.04	74.78	1.20	47.55	0.43	53.27	1.12	0.83	17.43	1.52%	5.53%
9-May	0.42	2.52	1.73	32.95	73.25	1.17	41.40	0.41	53.86	1.08	0.85	16.94	1.51%	10.22%
10-May	0.50	2.52	2.32	35.81	99.26	1.59	54.24	0.60	78.65	1.49	1.25	23.69	1.56%	6.98%
11-May	0.32	1.90	2.00	36.40	90.80	1.45	46.59	0.51	76.87	1.31	1.23	20.84	1.52%	4.26%
12-May	0.37	0.74	2.03	38.49	92.60	1.48	49.82	0.55	70.16	1.33	1.14	21.60	1.57%	4.04%
13-May	0.95	1.91	1.45	42.58	71.23	1.14	30.02	0.33	51.90	1.09	0.81	17.02	1.20%	4.04%
14-May	3.26	29.31	1.52	38.52	83.90	1.34	46.22	0.51	59.18	1.18	0.92	18.48	1.70%	6.58%
15-May	1.09	8.70	0.85	35.76	35.76	0.57	12.88	0.12	39.03	0.66	0.58	9.79	0.73%	3.84%
16-May	0.31	2.16	1.24	40.46	65.59	1.12	40.95	0.37	50.07	1.05	0.75	15.79	1.44%	4.24%
17-May	0.54	3.25	2.28	36.06	104.90	1.68	49.20	0.64	90.03	1.53	1.43	24.33	1.63%	3.91%
18-May	0.58	2.91	1.26	45.04	74.13	1.26	47.31	0.47	54.38	1.14	0.84	17.59	1.66%	9.90%
19-May	0.52	1.57	1.69	33.89	72.49	1.23	36.88	0.41	65.92	1.25	1.01	19.27	1.30%	4.60%
20-May	0.58	1.75	1.52	41.72	90.88	1.55	56.81	0.57	87.19	1.40	1.33	21.28	1.65%	1.90%
21-May	0.54	4.30	2.15	37.29	89.07	1.51	51.62	0.57	89.99	1.53	1.40	23.86	1.47%	1.93%
22-May	0.45	2.72	2.32	32.69	94.35	1.60	55.84	0.61	81.84	1.56	1.31	24.88	1.52%	5.90%
23-May	0.61	2.43	2.27	34.04	96.77	1.65	55.71	0.61	84.94	1.53	1.38	24.78	1.53%	4.11%
24-May	0.50	3.02	2.20	33.74	92.66	1.58	52.10	0.57	86.82	1.48	1.41	23.88	1.48%	5.29%
25-May	0.44	1.77	1.18	36.72	58.15	0.99	29.81	0.30	47.97	0.86	0.74	13.39	1.37%	4.91%
26-May	0.86	1.72	1.80	40.25	79.57	1.35	46.63	0.47	60.25	1.27	0.96	20.22	1.42%	4.46%
27-May	1.02	1.02	1.34	34.77	59.18	1.01	28.12	0.34	57.06	0.97	0.89	15.04	1.38%	5.17%
28-May	0.31	1.22	1.33	37.13	64.18	1.09	32.09	0.35	53.50	1.02	0.82	15.66	1.39%	4.82%
29-May	0.49	2.47	1.29	43.96	60.01	1.02	28.61	0.32	51.11	1.07	0.78	16.36	1.19%	4.77%
30-May	0.61	2.45	1.86	43.36	78.51	1.34	44.76	0.49	60.94	1.34	0.97	21.28	1.43%	3.73%
31-May	0.52	2.58	2.16	37.22	96.17	1.64	59.86	0.60	88.70	1.51	1.41	23.97	1.54%	4.88%
Average													1.46%	5.01%

Table 3: Daily Average Values for June

Date	Avg. Ambient Temp. (C)	Avg. Irradiance (kW/sq.m)	Total Irradiation (kWh/sq.m)	Avg. Panel Temp (C)	Solar Panel Fluid Inlet Temp (C)	Solar Panel Fluid Outlet Temp (C)	Avg. Panel Flow Rate (L/m)	Avg. Rate of Energy Transfer by Panels (kW)	Total Panel Energy Transfer (kWh)	Cold Water Supply Temp. (C)	Water Heater Outlet Temp (C)	Avg. DHW Flow Rate (L/m)	Avg. Rate Energy Transfer to DHW (kW)	Total Energy Transfer to Hot Water (kWh)
1-Jun	17.16	429.83	7.74	41.23	25.72	29.65	0.16	0.23	1.36	18.02	38.76	0.53	1.07	6.40
2-Jun	13.66	284.21	4.83	28.85	26.31	26.70	0.14	0.17	0.82	22.16	36.78	0.15	0.17	0.35
3-Jun	5.11	70.51	1.34	9.21	20.78	20.68	0.00	0.00	0.00	19.26	35.30	0.30	0.34	0.34
4-Jun	5.89	223.10	3.79	19.63	22.02	21.52	0.15	0.10	0.10	16.91	37.70	0.25	0.44	4.81
5-Jun	8.31	336.06	6.05	28.30	23.06	24.75	0.13	0.14	0.69	18.09	37.80	0.36	0.65	3.24
6-Jun	10.60	312.95	6.26	29.18	24.53	24.57	0.12	0.15	0.77	18.40	37.87	0.18	0.32	1.93
7-Jun	12.20	396.25	7.53	35.62	24.94	28.56	0.17	0.25	1.48	19.25	38.31	0.32	0.53	2.63
8-Jun	15.12	332.06	6.31	36.11	26.10	29.78	0.15	0.22	1.51	19.66	38.52	0.35	0.57	3.42
9-Jun	16.99	448.10	7.62	39.91	27.28	30.40	0.13	0.15	0.74	22.90	36.86	0.06	0.05	0.05
10-Jun	15.53	267.20	5.34	33.18	28.17	29.93	0.19	0.17	0.87	22.86	36.49	0.06	0.04	0.04
11-Jun	10.37	190.20	4.18	25.01	25.79	26.86	0.17	0.18	0.73	18.45	39.40	0.27	0.51	4.06
12-Jun	7.57	153.89	2.92	17.58	23.25	22.41	0.24	0.09	0.09	17.78	39.18	0.24	0.45	3.16
13-Jun	1.39	86.65	2.08	7.87	20.28	19.56	0.00	0.00	0.00	17.36	38.64	0.29	0.57	5.16
14-Jun	7.61	192.63	4.62	24.54	23.36	23.16	0.23	0.39	1.18	17.35	39.21	0.25	0.48	5.30
15-Jun	10.62	299.47	6.59	31.23	24.76	25.05	0.14	0.19	1.13	17.38	39.96	0.24	0.46	5.54
16-Jun	13.14	453.65	7.71	38.69	23.74	28.32	0.20	0.27	1.09	21.41	36.46	0.06	0.05	0.05
17-Jun	13.81	306.99	6.45	35.23	25.01	29.17	0.17	0.27	1.34	21.93	36.02	0.03	0.02	0.05
18-Jun	9.74	315.87	7.27	32.54	22.47	26.41	0.23	0.37	1.84	18.79	38.99	0.54	1.20	7.19
19-Jun	12.22	446.70	7.59	37.50	23.57	27.61	0.16	0.24	1.45	19.72	39.16	0.22	0.40	3.21
20-Jun	14.36	402.96	7.66	38.74	23.31	27.88	0.17	0.26	1.59	18.61	38.86	0.59	1.26	10.10
21-Jun	18.42	434.04	7.38	42.18	23.10	28.33	0.20	0.34	1.72	19.79	38.98	0.37	0.68	3.39
22-Jun	20.31	371.78	7.44	43.87	22.88	30.01	0.30	0.57	2.28	19.98	37.04	0.83	1.58	9.47
23-Jun	17.35	178.38	3.39	27.94	25.25	25.66	0.14	0.16	0.49	21.66	33.59	0.12	0.09	0.54
24-Jun	18.15	386.98	7.35	41.61	25.33	30.10	0.16	0.19	1.16	23.01	33.21	0.05	0.03	0.11
25-Jun	15.03	349.32	6.64	36.62	22.48	26.62	0.13	0.26	1.84	18.84	35.97	1.66	2.52	22.66
26-Jun	15.74	193.79	3.49	26.57	22.25	21.15	0.06	0.08	0.24	19.55	38.73	0.40	0.80	4.02
27-Jun	20.30	388.18	7.38	43.91	23.01	28.18	0.12	0.18	1.45	19.93	39.00	0.46	1.00	2.99
28-Jun	18.61	350.71	7.37	43.01	24.26	29.82	0.19	0.26	1.31	19.94	38.52	0.42	0.70	2.81
29-Jun	17.97	385.30	6.94	40.85	24.38	30.14	0.14	0.23	1.35	20.06	37.20	0.44	0.88	5.31
30-Jun	18.44	362.89	6.17	37.00	26.58	27.23	0.10	0.13	0.79	23.59	33.16	0.00	0.00	0.00

Table 3: Daily Average Values for June

Date	Average Water Heater Power (kW)	Total Water Heater Energy Consumed (kWh)	Avg. DC Current (A)	Avg. DC Voltage (V)	Avg. DC Power (W)	Total DC Energy (kWh)	Avg. Inverter Output (W)	Total Inverter Energy (kWh)	Est. Inverter Avg. Ouput (W)	Total Est. Inverter Ouput (kWh)	Avg. Solar Energy Input (kW)	Total Solar Energy Input (kWh)	Avg. Overall Electrical Efficiency	Avg. Overall Thermal Efficiency
1-Jun	0.31	2.50	2.19	36.47	93.61	1.59	61.49	0.62	84.25	1.52	1.36	24.55	1.55%	5.55%
2-Jun	0.85	1.70	1.38	34.99	60.16	1.02	31.15	0.31	58.61	1.00	0.90	15.33	1.26%	5.37%
3-Jun	1.01	1.01	0.25	31.36	9.29	0.16	1.17	0.00	15.88	0.30	0.22	4.25	0.06%	0.00%
4-Jun	0.61	3.07	0.87	42.22	45.00	0.77	14.04	0.15	47.93	0.82	0.71	12.04	0.79%	0.83%
5-Jun	0.88	2.64	1.73	37.02	73.42	1.25	34.16	0.38	68.55	1.23	1.07	19.20	1.21%	3.57%
6-Jun	0.42	2.52	1.55	41.61	81.68	1.39	39.29	0.47	64.91	1.30	0.99	19.86	1.46%	3.88%
7-Jun	0.28	2.25	2.26	30.52	93.83	1.60	59.49	0.60	78.75	1.50	1.26	23.89	1.54%	6.19%
8-Jun	0.17	1.22	1.84	33.12	82.01	1.39	48.73	0.54	65.19	1.24	1.05	20.02	1.65%	7.53%
9-Jun	0.55	1.64	2.16	33.44	94.10	1.60	48.96	0.59	89.50	1.52	1.42	24.17	1.50%	3.06%
10-Jun	0.40	0.81	1.48	35.53	65.16	1.11	27.96	0.31	54.25	1.09	0.85	16.96	1.12%	5.13%
11-Jun	0.37	2.92	1.17	34.13	52.98	0.90	27.90	0.28	39.23	0.86	0.60	13.28	1.30%	5.48%
12-Jun	0.32	2.58	0.75	30.52	33.00	0.56	14.48	0.12	32.97	0.63	0.49	9.28	0.77%	0.97%
13-Jun	0.56	2.77	0.17	26.76	4.69	0.08	0.27	0.00	19.59	0.47	0.28	6.60	0.01%	0.00%
14-Jun	0.39	3.49	1.10	49.45	53.74	0.91	20.19	0.22	40.50	0.97	0.61	14.67	0.93%	8.05%
15-Jun	0.35	4.84	1.58	39.41	86.16	1.47	42.94	0.52	61.54	1.35	0.95	20.91	1.52%	5.41%
16-Jun	0.26	1.28	2.24	34.85	95.30	1.62	55.24	0.61	89.26	1.52	1.44	24.47	1.53%	4.45%
17-Jun	0.22	0.88	1.94	30.80	77.63	1.32	47.03	0.52	60.93	1.28	0.97	20.46	1.56%	6.54%
18-Jun	0.78	6.97	2.10	36.32	90.70	1.54	46.64	0.56	63.67	1.46	1.00	23.05	1.50%	7.96%
19-Jun	0.34	3.04	2.24	33.55	93.25	1.59	57.36	0.57	88.94	1.51	1.42	24.10	1.47%	6.01%
20-Jun	1.19	7.14	2.21	32.07	92.23	1.57	49.71	0.60	79.58	1.51	1.28	24.30	1.52%	6.52%
21-Jun	0.38	2.64	2.19	32.46	90.73	1.54	48.55	0.58	85.17	1.45	1.38	23.42	1.54%	7.35%
22-Jun	1.30	7.80	2.25	30.88	91.71	1.56	48.63	0.58	72.74	1.46	1.18	23.60	1.53%	9.65%
23-Jun	0.48	1.43	0.84	36.51	35.54	0.60	13.34	0.16	37.56	0.71	0.57	10.76	0.92%	4.57%
24-Jun	0.22	0.88	2.05	33.16	95.05	1.62	48.78	0.59	76.21	1.45	1.23	23.33	1.55%	4.98%
25-Jun	1.99	17.90	1.87	35.88	84.40	1.44	43.21	0.48	70.31	1.34	1.11	21.06	1.39%	8.76%
26-Jun	0.76	4.53	0.83	37.02	41.32	0.70	19.65	0.18	41.06	0.74	0.62	11.07	0.99%	2.18%
27-Jun	0.44	3.49	2.07	36.37	93.60	1.59	48.16	0.58	76.35	1.45	1.23	23.41	1.53%	6.20%
28-Jun	0.38	1.90	2.14	33.07	92.57	1.57	51.43	0.57	69.08	1.45	1.11	23.37	1.50%	5.58%
29-Jun	0.55	3.84	1.67	39.88	93.94	1.60	55.57	0.61	75.84	1.37	1.22	22.01	1.71%	6.14%
30-Jun	0.50	1.49	1.59	38.40	77.52	1.32	31.96	0.42	74.03	1.26	1.15	19.58	1.31%	4.02%
Average												1.27%	5.06%	

Table 4: Daily Average Values for July

Date	Avg. Ambient Temp. (C)	Avg. Irradiance (kW/sq.m)	Total Irradiation (kWh/sq.m)	Avg. Panel Temp (C)	Solar Panel Fluid Inlet Temp (C)	Solar Panel Fluid Outlet Temp (C)	Avg. Panel Flow Rate (L/m)	Avg. Rate of Energy Transfer by Panels (kW)	Total Panel Energy Transfer (kWh)	Cold Water Supply Temp. (C)	Water Heater Outlet Temp (C)	Avg. DHW Flow Rate (L/m)	Avg. Rate Energy Transfer to DHW (kW)	Total Energy Transfer to Hot Water (kWh)
1-Jul	21.04	440.36	7.49	45.24	27.07	32.05	0.11	0.13	0.87	23.64	33.43	0.05	0.03	0.13
2-Jul	21.28	375.53	7.51	44.41	25.63	31.72	0.11	0.17	1.02	20.79	35.09	0.55	1.03	6.17
3-Jul	22.35	423.97	7.63	45.82	26.22	31.78	0.11	0.16	1.15	20.30	34.64	0.44	0.63	3.16
4-Jul	20.59	160.98	2.74	29.85	26.53	27.28	0.10	0.05	0.21	22.71	33.63	0.00	0.00	0.00
5-Jul	18.93	125.59	2.51	27.09	25.54	25.92	0.10	0.05	0.25	19.77	34.57	0.31	0.54	3.23
6-Jul	19.30	291.73	6.13	39.69	20.13	26.38	0.12	0.23	1.59	18.73	34.46	1.59	2.96	20.69
7-Jul	19.75	341.14	6.82	42.91	23.37	29.48	0.12	0.16	0.80	22.88	33.66	0.00	0.00	0.00
8-Jul	20.87	354.20	6.73	43.45	26.05	31.06	0.13	0.18	1.40	23.43	33.81	0.00	0.00	0.00
9-Jul	18.51	187.90	3.95	32.59	26.50	27.93	0.12	0.15	0.75	21.86	34.54	0.14	0.26	0.77
10-Jul	17.31	200.26	4.01	31.87	25.45	27.46	0.12	0.20	0.39	20.40	36.06	0.35	0.55	4.42
11-Jul	18.74	355.19	6.39	40.58	25.74	31.35	0.09	0.12	1.11	19.67	35.27	0.33	0.57	5.09
12-Jul	18.37	311.22	6.85	40.82	23.32	31.14	0.09	0.17	1.18	19.52	34.81	0.59	1.14	6.83
13-Jul	16.15	276.38	5.53	34.22	24.21	28.56	0.14	0.35	1.04	19.86	36.45	0.27	0.47	3.31
14-Jul	16.16	253.01	5.06	32.97	25.10	29.42	0.06	0.09	0.27	21.95	36.61	0.06	0.05	0.05
15-Jul	14.44	232.36	4.88	29.70	26.39	28.56	0.14	0.12	0.48	22.26	35.93	0.06	0.04	0.09
16-Jul	15.54	354.74	6.39	35.80	25.87	30.46	0.08	0.11	0.76	19.98	37.93	0.28	0.45	1.34
17-Jul	14.28	233.25	4.90	30.97	25.28	28.66	0.12	0.17	0.83	20.15	37.72	0.21	0.32	2.25
18-Jul	13.48	256.35	5.38	31.69	24.60	29.26	0.09	0.14	0.58	19.84	38.16	0.38	0.66	1.98
19-Jul	16.03	373.91	7.10	39.47	26.20	30.48	0.08	0.12	0.61	20.01	38.34	0.40	0.65	3.91
20-Jul	18.74	386.69	6.96	42.05	26.58	32.54	0.08	0.15	0.88	21.13	38.37	0.24	0.37	1.48
21-Jul	17.30	332.11	6.97	39.08	26.83	32.27	0.10	0.15	0.77	21.81	36.78	0.12	0.09	0.09
22-Jul	15.77	404.75	7.69	39.44	27.28	31.83	0.09	0.11	0.65	23.51	37.20	0.00	0.00	0.00
23-Jul	15.93	337.93	6.76	37.89	26.64	31.50	0.09	0.14	1.00	20.05	38.29	0.26	0.46	3.67
24-Jul	18.19	414.92	7.47	42.19	22.01	29.20	0.13	0.14	0.68	19.11	36.48	2.85	4.02	24.13
25-Jul	18.66	380.43	7.61	42.58	20.98	28.30	0.07	0.17	1.00	20.29	38.85	0.18	0.27	1.07
26-Jul	18.46	380.23	7.61	43.23	23.05	29.91	0.12	0.21	1.06	20.86	38.12	0.18	0.28	1.42
27-Jul	20.03	478.15	7.65	44.65	19.48	30.86	0.06	0.06	0.12	18.65	34.51	3.53	3.48	31.35
28-Jul	20.79	387.72	6.98	39.31	21.92	29.13	0.06	0.07	0.14	21.94	37.24	0.16	0.22	0.67
29-Jul	15.40	282.32	5.65	34.33	23.71	30.47	0.06	0.07	0.07	21.82	36.60	0.18	0.18	0.36
30-Jul	14.16	289.23	6.07	34.60	24.54	29.76	0.06	0.07	0.07	20.99	38.43	0.18	0.28	2.50
31-Jul	13.77	245.55	5.16	28.83	23.70	25.51	0.00	0.00	0.00	20.00	38.81	0.42	0.81	6.48

Table 4: Daily Average Values for July

Date	Average Water Heater Power (kW)	Total Water Heater Energy Consumed (kWh)	Avg. DC Current (A)	Avg. DC Voltage (V)	Avg. DC Power (W)	Total DC Energy (kWh)	Avg. Inverter Output (W)	Total Inverter Energy (kWh)	Est. Inverter Avg. Ouput (W)	Total Est. Inverter Ouput (kWh)	Avg. Solar Energy Input (kW)	Total Solar Energy Input (kWh)	Avg. Overall Electrical Efficiency	Avg. Overall Thermal Efficiency
1-Jul	0.10	0.88	2.17	34.21	90.01	1.53	62.03	0.56	86.50	1.47	1.40	23.76	1.45%	3.68%
2-Jul	0.40	4.41	2.18	32.79	91.25	1.55	51.84	0.57	73.39	1.47	1.19	23.83	1.48%	4.28%
3-Jul	0.20	1.96	1.98	37.27	97.47	1.66	50.89	0.61	82.74	1.49	1.35	24.22	1.56%	4.74%
4-Jul	0.21	0.82	0.53	45.16	29.07	0.49	4.75	0.04	34.45	0.59	0.51	8.68	0.31%	2.44%
5-Jul	0.21	1.90	0.43	36.84	23.17	0.39	5.13	0.05	26.89	0.54	0.40	7.97	0.40%	3.14%
6-Jul	1.81	18.11	1.78	36.44	80.96	1.38	41.64	0.50	57.49	1.21	0.93	19.44	1.59%	8.16%
7-Jul	0.15	0.75	1.85	40.20	89.09	1.52	46.58	0.51	67.21	1.34	1.08	21.65	1.46%	3.67%
8-Jul	0.23	1.58	1.92	35.16	89.86	1.53	44.37	0.53	69.60	1.32	1.12	21.36	1.54%	6.55%
9-Jul	0.37	1.83	1.04	38.57	51.39	0.87	21.29	0.21	38.27	0.80	0.60	12.52	1.05%	5.99%
10-Jul	0.26	2.10	1.08	37.45	54.14	0.92	28.97	0.26	40.84	0.82	0.64	12.71	1.27%	3.07%
11-Jul	0.23	2.73	1.81	35.40	84.89	1.44	50.14	0.55	69.65	1.25	1.13	20.29	1.68%	5.49%
12-Jul	0.55	5.54	2.05	36.37	87.64	1.49	47.22	0.57	60.94	1.34	0.99	21.73	1.61%	5.41%
13-Jul	0.16	1.91	1.52	36.44	70.50	1.20	34.81	0.38	56.02	1.12	0.88	17.54	1.35%	5.95%
14-Jul	0.29	1.44	1.50	29.87	65.82	1.12	43.16	0.39	50.20	1.00	0.80	16.06	1.49%	1.68%
15-Jul	0.22	0.89	1.27	34.92	61.47	1.05	29.33	0.35	48.00	1.01	0.74	15.48	1.40%	3.07%
16-Jul	0.17	1.90	1.83	35.46	83.23	1.42	39.58	0.52	70.53	1.27	1.13	20.26	1.57%	3.75%
17-Jul	0.14	1.58	1.24	38.54	61.97	1.05	32.70	0.33	47.58	1.00	0.74	15.54	1.30%	5.35%
18-Jul	0.17	2.06	1.37	37.97	65.88	1.12	33.54	0.40	52.63	1.11	0.81	17.08	1.45%	3.37%
19-Jul	0.19	1.85	2.00	37.21	91.63	1.56	52.16	0.57	73.75	1.40	1.19	22.54	1.57%	2.72%
20-Jul	0.15	1.66	1.79	43.10	91.07	1.55	53.77	0.54	76.27	1.37	1.23	22.09	1.50%	4.00%
21-Jul	0.39	1.55	1.65	41.29	90.03	1.53	47.98	0.58	65.66	1.38	1.05	22.13	1.61%	3.48%
22-Jul	0.24	0.95	2.26	36.88	94.31	1.60	56.80	0.63	80.29	1.53	1.28	24.40	1.58%	2.66%
23-Jul	0.33	2.64	2.04	33.11	87.11	1.48	56.33	0.56	66.60	1.33	1.07	21.45	1.62%	4.65%
24-Jul	1.11	21.14	2.06	36.45	96.55	1.64	55.78	0.61	81.20	1.46	1.32	23.70	1.60%	2.85%
25-Jul	0.11	2.26	2.18	35.88	95.02	1.62	53.22	0.59	74.48	1.49	1.21	24.15	1.50%	4.12%
26-Jul	0.13	1.38	2.22	36.57	95.44	1.62	68.06	0.61	74.38	1.49	1.21	24.13	1.57%	4.38%
27-Jul	2.58	30.92	2.28	35.40	96.18	1.64	62.28	0.62	92.88	1.49	1.52	24.28	1.59%	0.49%
28-Jul	0.50	1.50	2.08	34.87	87.28	1.48	44.04	0.57	76.63	1.38	1.23	22.15	1.60%	0.62%
29-Jul	0.88	0.88	1.37	39.24	75.38	1.28	37.34	0.45	56.34	1.13	0.90	17.92	1.54%	0.36%
30-Jul	0.34	2.05	1.78	38.18	77.00	1.31	40.17	0.40	58.99	1.24	0.92	19.27	1.29%	0.34%
31-Jul	0.89	4.45	1.14	45.74	71.73	1.15	27.99	0.36	51.32	1.08	0.78	16.36	1.37%	NC
Average													1.42%	3.68%

Table 5: Daily Average Values for August

Date	Avg. Ambient Temp. (C)	Avg. Irradiance (kW/sq.m)	Total Irradiation (kWh/sq.m)	Avg. Panel Temp (C)	Solar Panel Fluid Inlet Temp (C)	Solar Panel Fluid Outlet Temp (C)	Avg. Panel Flow Rate (L/m)	Avg. Rate of Energy Transfer by Panels (kW)	Total Panel Energy Transfer (kWh)	Cold Water Supply Temp. (C)	Water Heater Outlet Temp (C)	Avg. DHW Flow Rate (L/m)	Avg. Rate Energy Transfer to DHW (kW)	Total Energy Transfer to Hot Water (kWh)
1-Aug	15.67	446.31	7.59	40.51	22.35	30.76	0.06	0.06	0.24	19.45	39.03	0.47	0.95	3.81
2-Aug	20.52	420.13	7.56	45.25	23.59	31.67	0.06	0.11	0.32	19.74	37.76	0.26	0.39	2.69
3-Aug	22.05	189.57	4.36	35.47	23.66	29.62	0.06	0.04	0.04	19.59	38.92	0.24	0.41	2.85
4-Aug	21.22	296.56	6.23	39.60	26.24	31.57	0.06	0.04	0.13	23.10	37.75	0.30	0.37	0.75
5-Aug	19.65	379.99	7.60	43.96	27.23	33.80	0.06	0.06	0.25	24.30	37.85	0.00	0.00	0.00
6-Aug	22.34	342.89	7.20	45.83	27.02	33.51	0.09	0.13	0.53	21.04	39.13	0.36	0.58	3.49
7-Aug	23.37	309.24	6.49	45.37	26.80	33.35	0.06	0.05	0.18	20.82	39.14	0.18	0.29	1.43
8-Aug	20.89	339.39	7.13	42.66	22.78	30.56	0.00	0.04	0.11	19.95	38.97	0.62	1.25	7.53
9-Aug	16.04	423.88	6.36	35.52	23.77	26.74	0.00	0.02	0.02	19.92	39.02	0.37	0.66	5.30
10-Aug	18.96	473.53	7.58	44.25	23.71	31.21	0.06	0.05	0.21	19.76	38.44	0.27	0.43	3.03
11-Aug	19.95	399.26	7.19	43.45	23.69	30.86	0.06	0.05	0.30	21.18	36.06	0.06	0.05	0.05
12-Aug	20.60	373.85	7.48	45.05	24.51	31.70	0.06	0.04	0.21	21.30	35.60	0.00	0.00	0.00
13-Aug	20.34	216.05	4.54	35.30	24.14	28.76	0.06	0.04	0.09	20.18	37.35	0.25	0.37	2.21
14-Aug	18.58	283.60	5.67	38.07	25.10	30.71	0.06	0.03	0.03	20.07	37.28	0.23	0.33	1.32
15-Aug	18.53	348.33	6.62	41.12	23.53	29.76	0.06	0.05	0.15	19.09	37.05	0.33	0.49	2.92
16-Aug	19.61	407.89	7.34	43.23	23.67	30.87	0.06	0.04	0.13	19.26	37.32	0.18	0.39	0.39
17-Aug	22.38	433.88	7.38	45.21	25.39	32.18	0.10	0.11	0.64	20.67	37.09	0.12	0.17	0.49
18-Aug	23.65	361.63	5.79	42.19	26.56	31.82	0.06	0.07	0.21	22.64	36.34	0.00	0.00	0.00
19-Aug	18.90	387.03	7.35	42.04	27.24	33.44	0.12	0.06	0.17	22.82	36.28	0.00	0.00	0.00
20-Aug	18.83	411.94	7.42	43.29	26.65	32.39	0.06	0.09	0.35	20.56	38.87	0.27	0.50	2.02
21-Aug	19.12	375.66	7.51	42.53	25.65	32.47	0.07	0.10	0.68	21.35	39.24	0.34	0.58	4.61
22-Aug	20.07	349.19	7.33	43.81	26.07	32.96	0.06	0.05	0.15	20.43	38.79	0.19	0.32	1.92
23-Aug	21.61	269.04	5.65	36.25	23.47	29.46	0.00	0.06	0.06	19.79	39.22	0.74	1.46	10.23
24-Aug	17.25	366.69	6.60	39.13	21.59	28.71	0.09	0.08	0.31	19.28	38.24	0.37	0.65	3.89
25-Aug	16.88	447.99	7.62	41.41	24.17	30.90	0.06	0.06	0.23	21.51	37.01	0.18	0.20	0.40
26-Aug	19.41	385.61	7.71	43.39	25.89	32.67	0.06	0.06	0.30	23.03	37.31	0.00	0.00	0.00
27-Aug	19.87	326.69	5.88	39.08	26.17	32.57	0.00	0.02	0.02	20.98	38.85	0.24	0.41	1.23
28-Aug	20.03	380.12	7.22	43.06	25.75	32.32	0.09	0.07	0.37	20.30	37.37	0.49	0.75	3.76
29-Aug	18.30	388.76	7.39	42.66	25.35	31.76	0.06	0.04	0.22	19.81	35.81	0.32	0.48	3.81
30-Aug	20.38	493.12	7.40	44.46	24.44	32.05	0.06	0.06	0.22	20.12	34.82	0.35	0.54	3.24
31-Aug	20.38	334.95	5.36	38.28	26.58	27.37	0.06	0.11	0.11	21.22	35.06	0.16	0.20	0.61

Table 5: Daily Average Values for August

Date	Average Water Heater Power (kW)	Total Water Heater Energy Consumed (kWh)	Avg. DC Current (A)	Avg. DC Voltage (V)	Avg. DC Power (W)	Total DC Energy (kWh)	Avg. Inverter Output (W)	Total Inverter Energy (kWh)	Est. Inverter Avg. Ouput (W)	Total Est. Inverter Ouput (kWh)	Avg. Solar Energy Input (kW)	Total Solar Energy Input (kWh)	Avg. Overall Electrical Efficiency	Avg. Overall Thermal Efficiency
1-Aug	0.49	3.45	2.18	36.01	96.06	1.63	56.39	0.62	87.28	1.48	1.42	24.08	1.59%	1.00%
2-Aug	0.26	2.04	2.32	34.74	95.99	1.63	55.17	0.61	80.95	1.46	1.33	24.00	1.56%	1.31%
3-Aug	0.66	2.64	1.28	34.63	62.67	1.00	32.57	0.29	38.24	0.88	0.60	13.84	1.31%	0.26%
4-Aug	0.79	1.58	1.79	38.81	89.30	1.43	52.54	0.53	59.03	1.24	0.94	19.76	1.64%	0.64%
5-Aug	0.94	0.94	2.61	34.92	100.15	1.60	57.10	0.63	73.73	1.48	1.21	24.12	1.61%	1.05%
6-Aug	0.30	2.09	2.35	35.91	101.52	1.62	58.15	0.64	65.78	1.38	1.09	22.85	1.73%	2.32%
7-Aug	0.26	2.38	2.00	39.31	94.94	1.42	53.49	0.48	60.17	1.26	0.98	20.61	1.44%	0.89%
8-Aug	0.82	5.71	2.34	35.75	106.10	1.59	55.26	0.61	66.43	1.40	1.08	22.62	1.66%	0.47%
9-Aug	0.22	2.89	2.10	36.26	88.62	1.33	44.22	0.44	86.15	1.29	1.35	20.18	1.35%	0.10%
10-Aug	0.39	2.36	2.61	32.69	107.74	1.62	56.22	0.62	91.69	1.47	1.50	24.04	1.59%	0.85%
11-Aug	0.11	1.37	2.39	36.43	105.71	1.59	57.71	0.58	77.47	1.39	1.27	22.81	1.56%	1.32%
12-Aug	0.19	1.85	2.30	38.49	110.22	1.65	58.79	0.65	72.18	1.44	1.19	23.73	1.68%	0.89%
13-Aug	0.20	1.64	1.28	34.92	70.71	1.06	39.95	0.40	42.49	0.89	0.69	14.40	1.71%	0.60%
14-Aug	0.09	1.60	1.54	42.38	83.50	1.25	38.22	0.42	56.26	1.13	0.90	18.00	1.44%	0.16%
15-Aug	0.13	2.39	2.17	36.63	91.93	1.38	38.87	0.47	68.12	1.29	1.11	21.00	1.37%	0.71%
16-Aug	0.14	2.09	2.46	33.69	104.84	1.57	53.93	0.59	79.31	1.43	1.29	23.30	1.57%	0.57%
17-Aug	0.56	1.69	2.40	35.48	105.64	1.59	67.13	0.60	84.30	1.43	1.38	23.41	1.59%	2.72%
18-Aug	0.19	1.71	1.44	40.31	82.45	1.24	42.86	0.43	71.90	1.15	1.15	18.36	1.44%	1.14%
19-Aug	0.29	0.87	2.52	30.47	102.93	1.54	56.40	0.56	75.58	1.44	1.23	23.34	1.49%	0.72%
20-Aug	0.18	2.69	0.78	51.39	43.12	0.60	377.26	2.26	295.79	5.62	4.81	91.33	1.52%	0.38%
21-Aug	0.14	3.24	1.95	50.91	127.07	1.91	521.79	7.31	311.87	5.61	5.12	92.09	4.84%	0.74%
22-Aug	0.25	2.02	1.92	49.27	122.66	1.84	544.03	7.07	286.83	5.74	4.66	93.31	4.80%	0.16%
23-Aug	0.58	6.96	1.56	51.74	105.96	1.59	388.72	5.05	264.98	5.57	4.34	91.07	4.45%	0.07%
24-Aug	0.15	2.75	1.72	54.08	115.20	1.73	437.44	6.12	214.94	4.51	3.34	70.17	4.61%	0.44%
25-Aug	0.12	1.59	2.00	55.15	129.16	1.94	571.23	7.43	283.70	5.11	4.56	81.97	4.85%	0.28%
26-Aug	0.11	0.96	2.01	55.91	128.15	1.92	570.50	7.42	341.47	5.80	5.57	94.58	4.78%	0.31%
27-Aug	0.17	2.57	1.63	54.89	106.30	1.60	402.55	5.23	292.51	5.85	4.79	95.78	4.43%	0.02%
28-Aug	0.18	2.57	1.95	55.52	124.17	1.86	524.86	6.82	255.95	4.61	4.06	73.03	4.70%	0.51%
29-Aug	0.11	2.55	1.97	54.97	126.35	1.90	536.85	6.98	290.56	5.52	4.72	89.70	4.70%	0.24%
30-Aug	0.10	2.22	1.96	55.29	125.69	1.89	586.83	7.04	296.72	5.64	4.83	91.73	4.73%	0.24%
31-Aug	0.08	1.96	1.52	51.56	88.97	1.34	390.31	4.68	374.41	5.62	6.12	91.86	4.35%	0.12%
Average												2.65%	0.69%	

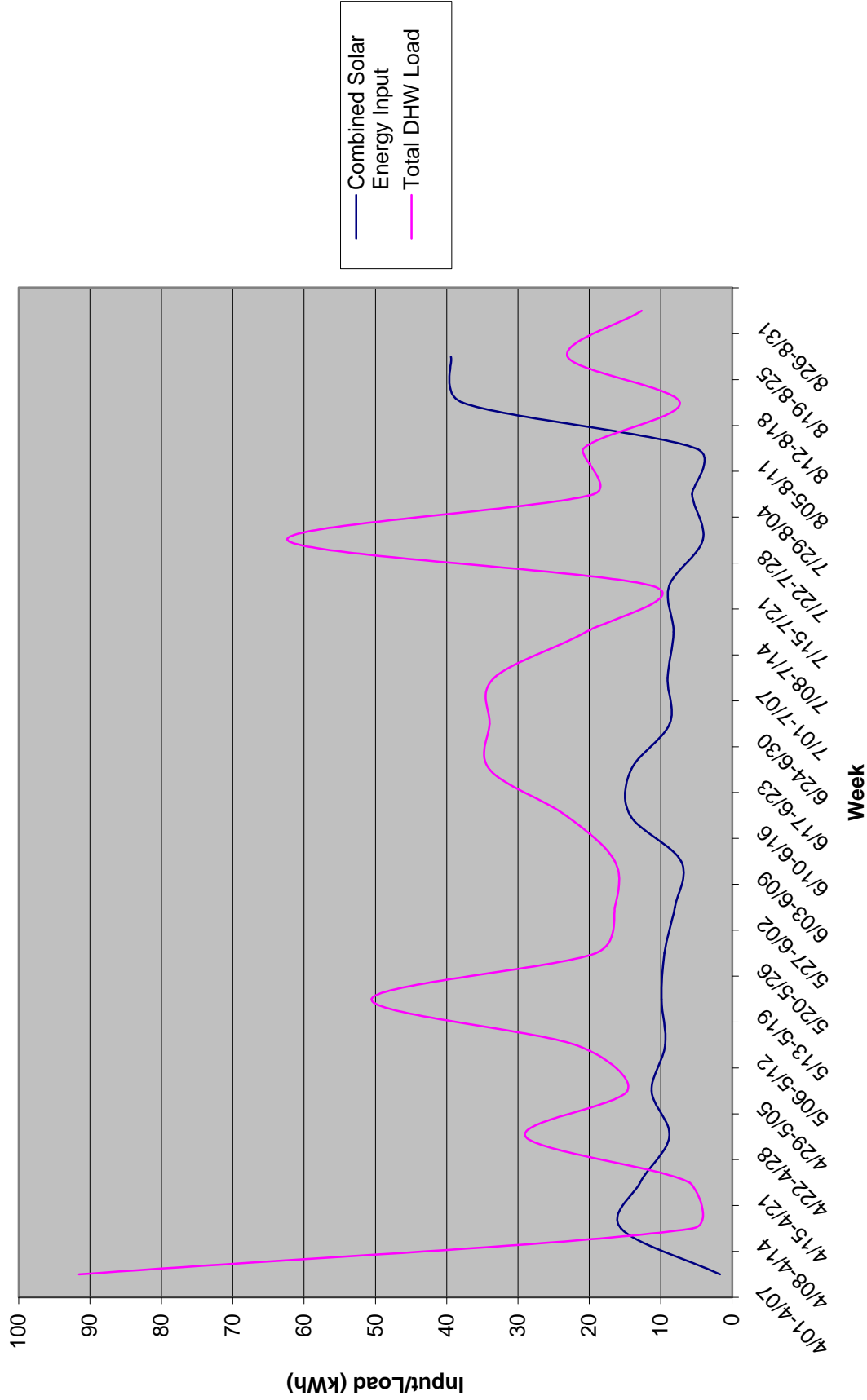
Table 6: Weekly, Monthly, and Period Totals

Weekly Totals	Avg. Ambient Temp. (C)	Avg. Irradiance (kW/sq.m)	Total Irradiation (kWh/sq.m)	Avg. Panel Temp (C)	Solar Panel Fluid Inlet Temp (C)	Solar Panel Fluid Outlet Temp (C)	Avg. Panel Flow Rate (L/m)	Avg. Rate of Energy Transfer by Panels (kW)	Total Panel Energy Transfer (kWh)	Cold Water Supply Temp. (C)	Water Heater Outlet Temp (C)	Avg. DHW Flow Rate (L/m)	Avg. Rate Energy Transfer to DHW (kW)	Total Energy Transfer to Hot Water (kWh)
4/01-4/07	3.22	323.95	41.43	21.19	24.74	24.92	0.42	0.45	16.00	16.80	27.94	1.37	1.26	91.56
4/08-4/14	0.28	191.99	25.85	12.49	21.91	19.25	0.07	0.04	0.38	18.92	29.49	0.13	0.19	5.57
4/15-4/21	3.98	382.78	40.46	22.54	22.01	22.66	0.21	0.26	12.34	17.63	30.51	0.12	0.21	5.96
4/22-4/28	10.53	323.36	43.36	29.41	23.12	25.71	0.25	0.31	9.51	18.23	34.30	0.28	0.57	28.93
4/29-5/05	6.34	289.46	38.21	23.39	23.63	24.72	0.19	0.22	6.02	18.80	33.54	0.21	0.33	14.67
5/06-5/12	10.86	359.87	47.44	31.81	24.56	26.27	0.20	0.26	7.51	18.76	35.67	0.26	0.50	21.87
5/13-5/19	12.38	285.61	38.52	28.45	23.23	23.05	0.20	0.27	6.53	18.25	37.49	0.58	0.83	50.54
5/20-5/26	13.92	384.06	47.99	34.70	24.28	26.10	0.16	0.20	6.18	19.05	38.07	0.23	0.42	19.08
5/27-6/02	13.46	321.02	41.66	31.87	25.11	26.63	0.18	0.22	6.46	19.27	37.57	0.27	0.46	16.42
6/03-6/09	10.60	302.72	38.90	28.28	24.10	25.75	0.12	0.14	5.28	19.21	37.48	0.26	0.41	16.43
6/10-6/16	9.46	234.81	33.46	25.44	24.19	25.04	0.17	0.19	5.09	18.94	38.48	0.20	0.37	23.30
6/17-6/23	15.17	350.96	47.17	36.86	23.66	27.87	0.20	0.32	10.70	20.07	37.52	0.39	0.75	33.94
6/24-6/30	15.80	362.39	48.07	37.77	23.70	28.00	0.19	0.31	10.52	20.22	37.12	0.39	0.75	34.00
7/01-7/07	20.46	308.47	40.83	39.29	24.93	29.23	0.11	0.14	5.89	21.26	34.21	0.42	0.74	33.37
7/08-7/14	18.01	276.88	38.51	36.64	25.19	29.56	0.11	0.18	6.14	20.95	35.36	0.25	0.43	20.48
7/15-7/21	15.69	309.91	42.58	35.54	25.96	30.32	0.10	0.14	4.91	20.74	37.60	0.24	0.37	11.13
7/22-7/28	18.26	397.73	51.76	41.33	23.05	30.10	0.09	0.13	4.63	20.63	37.24	1.02	1.25	62.31
7/29-8/04	17.54	309.95	42.61	36.94	23.97	29.91	0.05	0.05	0.85	20.67	38.19	0.29	0.48	19.43
8/05-8/11	20.17	381.17	49.54	43.00	25.00	31.43	0.05	0.06	1.60	20.99	38.37	0.27	0.47	20.82
8/12-8/18	20.53	346.46	44.81	41.45	24.70	30.83	0.07	0.05	1.45	20.46	36.86	0.16	0.25	7.33
8/19-8/25	18.95	372.51	49.48	41.21	24.98	31.47	0.07	0.07	1.94	20.82	38.24	0.30	0.53	23.06
8/26-8/31	19.73	384.87	40.96	41.82	25.69	31.46	0.06	0.06	1.24	20.91	36.54	0.26	0.40	12.66
Monthly Totals														
4/2001	4.78	297.54	159.02	21.39	22.87	23.10	0.23	0.26	38.83	17.92	30.67	0.45	0.53	132.98
5/2001	11.30	335.30	193.34	30.30	24.19	25.35	0.19	0.24	29.90	18.78	36.65	0.32	0.53	114.88
6/2001	13.39	311.69	177.41	32.46	24.13	26.67	0.15	0.21	31.40	19.75	37.52	0.33	0.60	118.30
7/2001	17.75	318.32	190.56	37.66	24.71	29.69	0.09	0.13	21.70	20.90	36.28	0.46	0.67	136.62
8/2001	19.85	366.54	210.53	41.66	24.93	31.24	0.06	0.06	6.96	20.75	37.64	0.25	0.43	73.96
Observation Period Totals														
4/01-8/31	13.42	325.88	930.85	32.69	24.17	27.21	0.15	0.18	128.78	19.62	36.75	0.36	0.55	576.74

Table 6: Weekly, Monthly, and Period Totals

	Average Water Heater Power (kW)	Total Water Heater Energy Consumed (kWh)	Avg. DC Current (A)	Avg. DC Voltage (V)	Avg. DC Power (W)	Total DC Energy (kWh)	Avg. Inverter Output (W)	Total Inverter Energy (kWh)	Est. Inverter Avg. Output (W)	Total Est. Inverter Output (kWh)	Avg. Solar Energy Input (kW)	Total Solar Energy Input (kWh)	Percent of DHW Load met by Combined Solar Input
Weekly Totals													
4/01-4/07	0.87	91.45	1.85	33.97	88.23	9.19	32.26	3.36	67.64	8.66	1.03	131.46	21.14%
4/08-4/14	0.32	27.87	1.09	33.48	49.06	5.14	12.90	1.32	41.33	5.56	0.61	82.03	30.54%
4/15-4/21	0.57	31.97	2.12	30.91	90.02	8.64	39.09	3.21	79.12	8.38	1.21	128.41	260.70%
4/22-4/28	0.77	24.73	1.95	37.89	88.74	9.32	42.83	3.36	65.60	8.80	1.03	137.61	44.50%
4/29-5/05	0.60	13.24	1.61	37.43	75.27	8.18	35.57	2.77	59.42	7.87	0.92	121.25	59.89%
5/06-5/12	0.56	16.88	2.08	34.90	91.20	10.21	50.02	3.77	72.13	9.51	1.14	150.56	51.57%
5/13-5/19	1.04	49.80	1.47	38.90	72.57	8.34	37.64	2.84	58.64	7.91	0.91	122.25	18.54%
5/20-5/26	0.57	17.71	1.92	36.64	85.92	10.23	49.79	3.70	77.00	9.61	1.22	152.29	51.76%
5/27-6/02	0.59	13.93	1.65	38.27	73.12	8.70	40.87	3.02	64.88	8.42	1.02	132.19	57.74%
6/03-6/09	0.56	14.34	1.52	35.61	68.48	8.15	35.12	2.72	61.53	7.91	0.96	123.43	48.74%
6/10-6/16	0.38	18.69	1.21	35.81	55.86	6.65	27.00	2.05	48.19	6.89	0.75	106.17	30.64%
6/17-6/23	0.67	29.90	1.97	33.23	81.68	9.72	44.47	3.57	69.80	9.38	1.11	149.67	42.06%
6/24-6/30	0.67	29.90	1.98	33.56	84.17	10.02	44.72	3.64	71.98	9.55	1.15	152.55	41.66%
7/01-7/07	0.44	28.83	1.56	37.56	71.58	8.52	37.55	2.85	61.24	8.10	0.98	129.55	26.16%
7/08-7/14	0.30	17.12	1.56	35.61	72.03	8.57	38.56	2.90	55.08	7.66	0.88	122.20	44.11%
7/15-7/21	0.20	11.49	1.59	38.36	77.90	9.27	41.29	3.28	62.06	8.54	0.98	135.14	73.60%
7/22-7/28	0.71	60.79	2.16	35.59	93.13	11.08	56.64	4.20	78.06	10.16	1.26	164.25	14.17%
7/29-8/04	0.61	17.08	1.69	38.19	81.16	9.44	43.17	3.26	61.74	8.50	0.98	135.23	21.14%
8/05-8/11	0.44	17.74	2.34	35.90	100.68	10.77	54.59	3.99	74.49	9.67	1.21	157.22	26.87%
8/12-8/18	0.21	12.98	1.94	37.41	92.76	9.74	48.54	3.56	67.79	8.77	1.10	142.19	68.37%
8/19-8/25	0.24	20.12	1.78	49.00	106.59	11.15	413.84	35.81	247.67	33.59	4.01	543.27	163.71%
8/26-8/31	0.13	12.82	1.84	54.69	116.60	10.50	501.98	38.18	308.60	33.04	5.01	536.68	311.48%
Monthly Totals													
4/2001	0.65	179.41	1.71	34.26	77.38	33.92	30.82	11.66	61.82	33.08	0.94	504.62	37.97%
5/2001	0.67	103.97	1.78	37.33	81.41	41.40	44.18	14.77	67.84	39.15	1.06	613.54	38.88%
6/2001	0.57	101.15	1.62	35.26	72.48	36.96	37.92	12.68	62.75	35.74	0.99	562.98	37.26%
7/2001	0.44	125.61	1.69	37.19	78.28	41.18	42.71	14.43	63.28	37.91	1.01	604.70	26.44%
8/2001	0.30	73.35	1.97	42.85	101.41	47.85	220.24	83.58	156.35	90.12	2.54	1461.03	122.41%
Observation Period Totals													
4/01-8/31	0.53	583.49	1.76	37.38	82.19	201.32	75.17	137.13	82.41	235.99	1.31	3746.88	46.11%

Total Weekly Solar Energy Input as a Percentage of Weekly DHW Load



Appendix B: Equations

Equations for Useful Collector Gain

$$Q_u = A_C F_R [S - U_L (T_{fi} - T_a)] \quad (1)_1$$

where: F_R is the Heat Removal Factor defined by

$$F_R = \frac{m C_p (T_{fo} - T_{fi})}{A_C [S - U_L (T_{fi} - T_a)]} \quad (2)_1$$

Insertion of Equation (2) into (1) yields the energy gained by the collector

$$Q_u = m C_p (T_{fo} - T_{fi}) \quad (3)_1$$

where:

m is the mass flow rate of the fluid

and

C_p is the heat capacity of the fluid

Equations for Absorbed Solar Radiation

$$S = (ta)_{av} I_T \times A_C \quad (4)_1$$

where:

I_T is the measured irradiance in the plane of the array

A_C is the area of the collector taken to be 5.138 sq. m*

$$(ta)_{av} \cong 0.96 (ta)_b \quad (5)_1$$

$$(ta)_b \cong K_{ta} (ta)_n \quad (6)_1$$

$$K_{ta} = 1.0 - 0.13((1/\cos q) - 1) \quad (7)_4$$

$$(ta)_n \cong 1.01 ta \quad (8)_1$$

and:

t is the transmissivity of the glazing given by the manufacturer as 0.91

a is the absorbtivity of the collector given by the manufacturer as 0.70

$(ta)_n$ is the transmittance-absorbtance product of the collector at normal angles of incidence

K_{ta} is the incident angle modifier

q is the irradiance incident angle calculated for each hour of each day for the location and tilt of the collectors.

Equations for Electrical Power

$$P_{DC} = V_{DC} \times I_{DC} \quad (9)$$

Estimated Power Output of the Inverter

$$P_{INV} = [1 + b(NOCT - ACT)]h_{MOD} h_{BOS} \times I_T \times A_C \quad (10)_3$$

where:

b is the temperature coefficient of cell efficiency taken to be 0.2% per °C

$NOCT$ is the normal cell operating temperature taken to be 25°C

ACT is the actual measured cell operating temperature

h_{MOD} is the assumed efficiency of the module taken to be 5.4%

h_{BOS} is the assumed efficiency of the combined balance of system components taken to be 80%

I_T is the measured irradiance in the plane of the array

A_C is the area of the collector taken to be 5.138 sq. m*

*Note: The available collector area was changed to 20.108 sq. m on August 20th

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