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SERF Photovoltaic Systems

Technical Report on System Performance for the Period 1 August 1994 - 31 July 1995

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Abstract

This report presents an analysis of performance data on the two identical, 6kW$_{ac}$, grid-connected photovoltaic systems located on the roof of the Solar Energy Research Facility building at the National Renewable Energy Laboratory in Golden, Colorado. The data cover the monitoring period August 1, 1994, to July 31, 1995, and the performance parameters analyzed include direct current and alternating current power, aperture-area efficiency, energy, capacity factor, and performance index. These parameters are compared to plane-of-array irradiance, ambient temperature, and back-of-module temperature as a function of time, either daily or monthly. We also obtained power ratings of the systems for data corresponding to different test conditions. This study has shown, in addition to expected seasonal trends, that system monitoring is a valuable tool in assessing performance and detecting faulty equipment. Furthermore, methods applied for this analysis may be used to evaluate and compare systems using cells of different technologies. The systems were both found to be operating at approximately 7% below their estimated rating, which was based on Photovoltaics for Utility-Scale Applications test conditions. This may be attributed to the design inverter efficiency being estimated at 95% compared to measured values of approximately 88%, as well as the fact that aperture-area efficiency that was overestimated at 12.8% compared to a measured value of 11.0%. The continuous monitoring also revealed faulty peak-power point tracking equipment.

1 Introduction

The aim of this study was to evaluate and compare the performance of two identical, 6-kW$_{ac}$, grid-connected photovoltaic (PV) systems located on the roof of the Solar Energy Research Facility (SERF) building at the National Renewable Energy Laboratory (NREL) in Golden, Colorado. The systems began operation on March 23, 1994. The evaluation was done by analyzing of performance data obtained by continuous system monitoring for the period August 1, 1994, to July 31, 1995. The key performance parameters reported here are direct current (dc) and alternating current (ac) power, aperture-area efficiency, energy, capacity factor, and performance index. The system power (dc and ac), when compared to plane-of-array (POA) irradiance and temperature (ambient and back-of-module) as a function of time, may be used to compute parameters such as PV array aperture-area efficiency, ac efficiency, and performance index, and also to monitor any deviation from expected seasonal variation. The energy output of the system was used to compute the capacity factor on a monthly basis and for the total monitoring period. The energy output was also simulated using

PVFORM. The system power rating as defined by different test conditions was determined. Finally, the various system losses were also evaluated.

Each system, comprising a mono-crystalline Si array, was estimated at 6 kW_{ac} under Photovoltaics for Utility-Scale Applications (PVUSA) test conditions (PTC)[1] when deployed. Each array consists of 140 Siemens Solar Industries M55 PV modules connected in the following configuration: five source circuits, each with one positive and one negative monopole; each monopole consists of 14 series-connected modules. The dc rating of each system at standard test conditions (STC)[2] is 7.43 kW. This rating was obtained by summation of nominal module peak power at STC, as determined by the manufacturer. The systems are mounted on the roof of the SERF building at a fixed tilt of 45° and are aligned with the building, at approximately 15° east of true south. The SERF building is located at 39.7°N latitude and 105°W longitude and the elevation is 1782 m (Strand, Mrig, and Hansen 1994). The systems are identified as SERFEAST and SERFWEST, corresponding to their position on the SERF building. The photograph in Figure 1 shows the SERFEAST array.

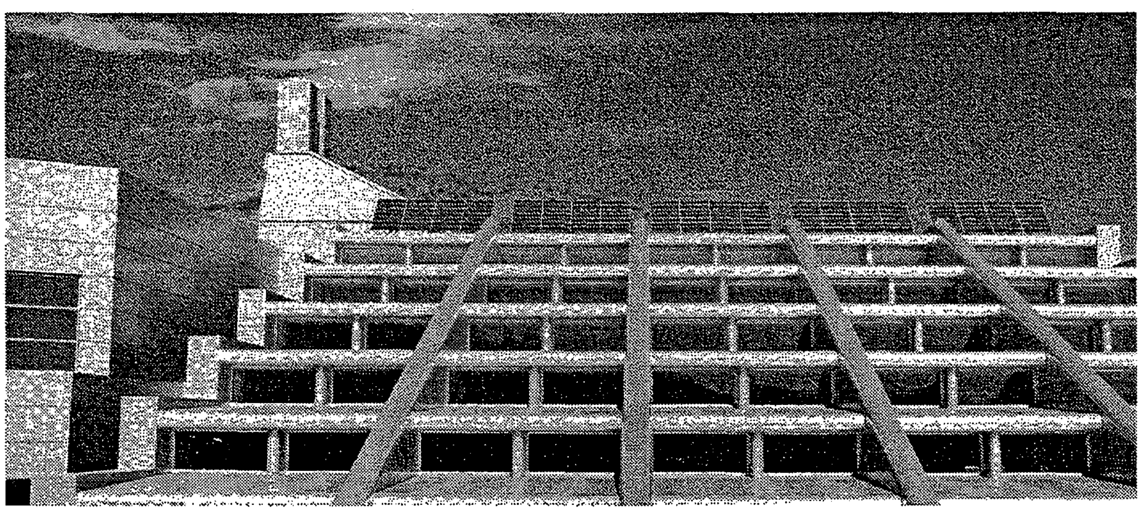

Figure 1. Photograph of SERFEAST array on the roof of the SERF building.

[1] PTC: PVUSA test conditions - 1000 W/m² POA irradiance, 20°C ambient temperature, and 1m/s wind speed.
[2] STC: Standard test conditions -1000 W/m² POA irradiance, 25°C cell temperature, and air mass 1.5 spectrum.

2 Experimental Procedure

The data acquisition of performance parameters is centered around Campbell Scientific[4] data loggers connected to a computer via modem link, with data sampled every 5 seconds and stored as 15-minute averages. The data were estimated to be accurate to within ±1%. A detailed description of the data acquisition system is given in Appendix C. In this study, the performance data were restricted to those collected for the year starting August 1, 1994, and ending July 31, 1995. The data were also restricted to POA irradiance greater than 850 W/m^2 for analysis of power and associated parameters, and to ±2°C about reference temperature for power-rating calculations.

3 Results and Discussion

All graphs shown in this section, unless otherwise stated, depict results obtained for the SERFEAST system. The same graphs for the SERFWEST system are included in Appendix A and numbered as Figure A.x, where x refers to the figures of Section 3. Furthermore, any inconsistencies between the two systems are dealt with below.

3.1 Power generation and associated parameters

In this section all figures, unless otherwise stated, are graphs of monitored parameters as functions of time. Figure 2 shows the as-measured dc power and POA irradiance. The heavy solid lines represent a 6th-order polynomial fit for each parameter. It must, however, be noted that these lines are included to serve merely as a guide to the eye and to reveal seasonal variations, and are not an attempt to model the parameter as a function of time. The expected correlation between dc power and POA irradiance is observed. A further parameter that influences dc power output is temperature. The influence of temperature is shown in Figure 3, in which the back-of-module temperature is plotted together with POA irradiance and aperture-area efficiency. The aperture-area efficiency is defined as the ratio P_{out}/P_{in}, where P_{in} is the POA irradiance over the net module area of the array and P_{out} is the dc power output. The heavy solid lines are 6th-order polynomial fits for each parameter. The observed inverse correlation between aperture-area efficiency and POA irradiance, and hence dc power, may be attributed to the influence of temperature. This is illustrated by the inverse correlation of aperture-area efficiency and back-of-module temperature observed in the figure. The annual average aperture-area efficiency for the above-mentioned data restrictions was determined to be 11.0%,

[4] Reference to a specific manufacturer's product does not constitute an endorsement by the U.S. Department of Energy or NREL, but refers to products that are representative of instruments used for the purposes described in this text.

compared with the design value of 12.8%. The annual minimum and maximum aperture-area efficiencies were 9.7% and 12.3%, respectively. This discrepancy may be attributed, in part, to various array losses that were not adequately accounted for and to prevailing weather conditions. The annual average aperture-area efficiency based on all the data collected was determined to be 10.5%.

Figures 2 and 3 clearly demonstrate the effect of temperature and POA irradiance fluctuation, with the correlation discussed above. Variations in performance resulting from POA irradiance and module temperature non-uniformities may be corrected for by POA irradiance normalization and temperature correction with respect to a reference measurement condition. In this case, STC were used as reference (i.e. normalized to 1000 W/m^2 and temperature corrected to 25°C). POA irradiance normalization is calculated by multiplying the performance parameter by the following factor: 1000 W.m^{-2} divided by measured POA irradiance. Temperature correction is calculated as follows:

$$P_C = P_N \times \left[1 + \left(25 - T_{bom}\right) \times \kappa / 100\right.$$

where: P_C and P_N are the corrected and normalized performance parameter (power in this case), respectively; T_{bom} is the back-of- module temperature in °C; and κ is the temperature coefficient expressed in %/°C. The temperature coefficient used for the power temperature corrections is $\kappa = -0.4334$ %/°C, as determined by Kroposki 1995.

After POA normalization and temperature correction, any deviation from expected performance is the result of losses associated with effects such as soiling, degradation, dc wire losses, and losses associated with power conversion. System losses are discussed in Subsection 3.4. Figures 4 and 5 show the effect of normalization and temperature correction. In Figure 4, the irradiance-normalized dc and ac power are plotted together with back-of-module temperature as a function of time, before temperature correction applied. The inverse correlation between power and temperature is clearly illustrated. Figure 5 shows normalized and temperature-corrected dc and ac power as a function of time. The heavy solid lines represent a 6th-order polynomial fit to each data set, which is used to demonstrate any deviation from linearity. The temperature coefficients used for temperature correction were determined using single modules (Kroposki 1995), which may attribute to the observed deviation from linearity in Figure 5. Furthermore, after temperature correction to 25°C back-of-module temperature and normalization to 1000 W/m^2, the system output at STC is about 6 kW_{ac}, as illustrated in Figure 5.

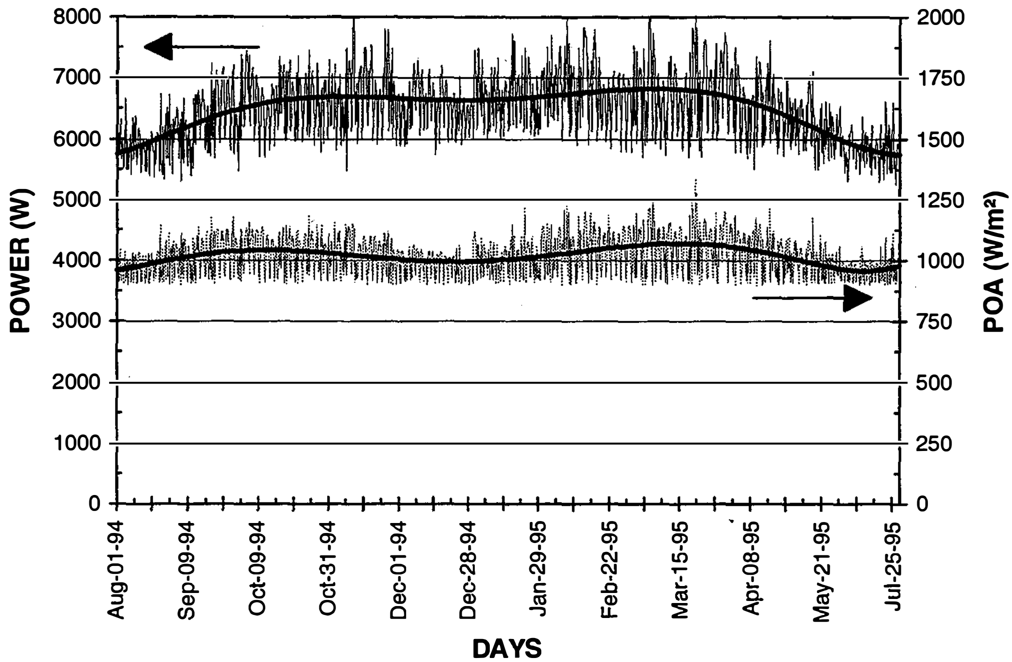

Figure 2. Plot of as-measured dc power and POA irradiance. The solid ilnes are 6th-order polynomial fits for respective data sets and are included to serve as a guide to the eye.

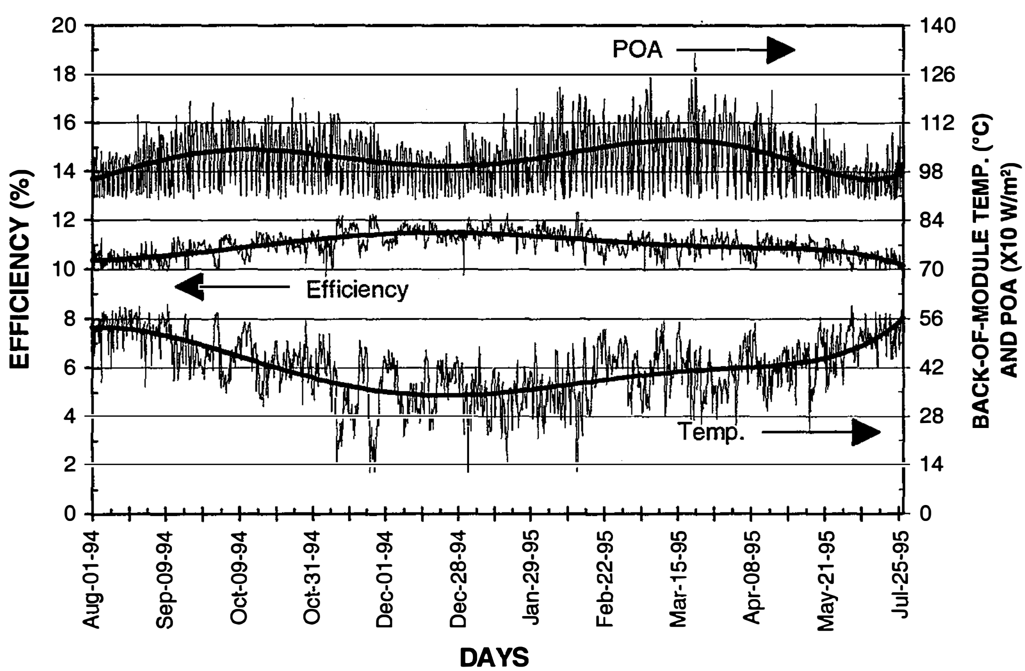

Figure 3. Plot of aperture efficiency, POA irradiance, and back-of-module temperature.

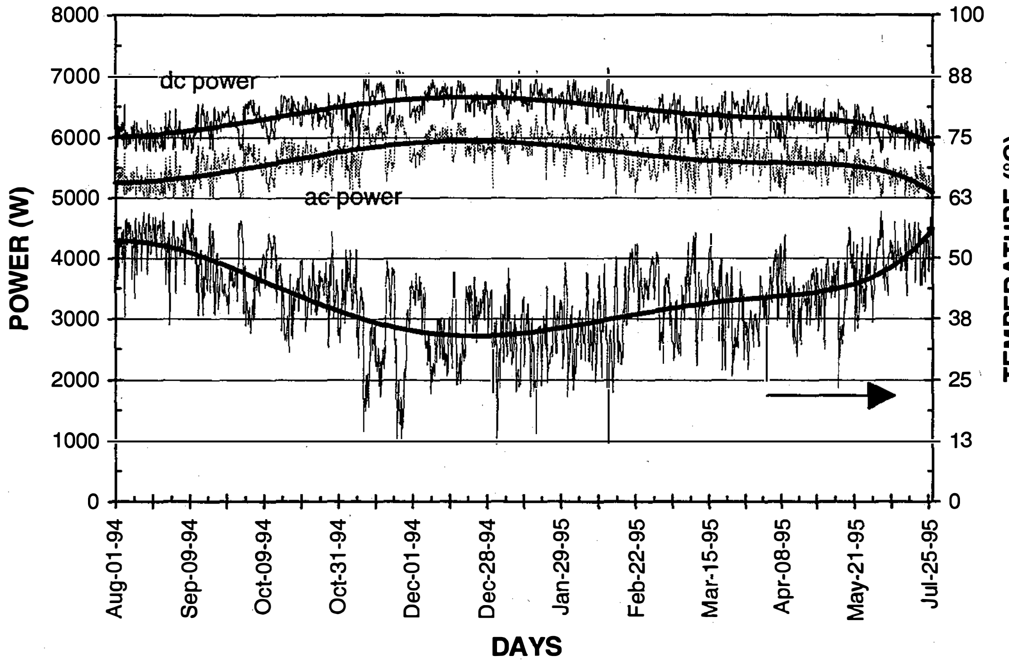

Figure 4. Plot of normalized dc and ac power and back-of-module temperature.

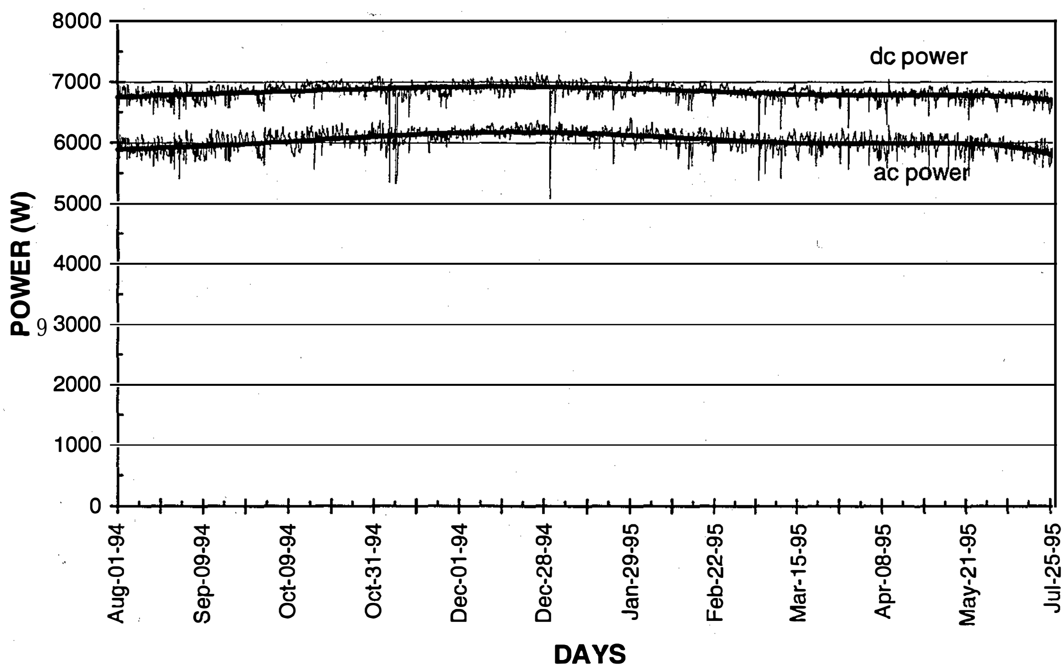

Figure 5. Plot of normalized and temperature-corrected dc and ac power.

3.2 Energy considerations

The incident energy, as determined from the POA irradiance and the total array area, is shown in Figure 6. The near-lattitude tilt of 45° yields the expected seasonal incident energy variation; with spring and fall maxima and corresponding winter and summer minima are also observed. The total annual dc energy produced by the two systems was 12.0 MWh and 11.8 MWh for SERFEAST and SERFWEST, respectively. The monthly energy produced shows variations caused by seasonal insolation and prevailing weather conditions. These variations (spring and fall maxima and corresponding winter and summer minima) are depicted in Figure 7, where the monthly energies for the SERFEAST and SERFWEST systems are plotted in (a) and (b), respectively. The typical seasonal variation is observed, except for the SERFEAST system in July 1995, which exhibits an unusually low energy production when compared to the SERFWEST system. This is because the peak-power tracker had a software error, resulting in the low energy production. This was corrected in August 1995.

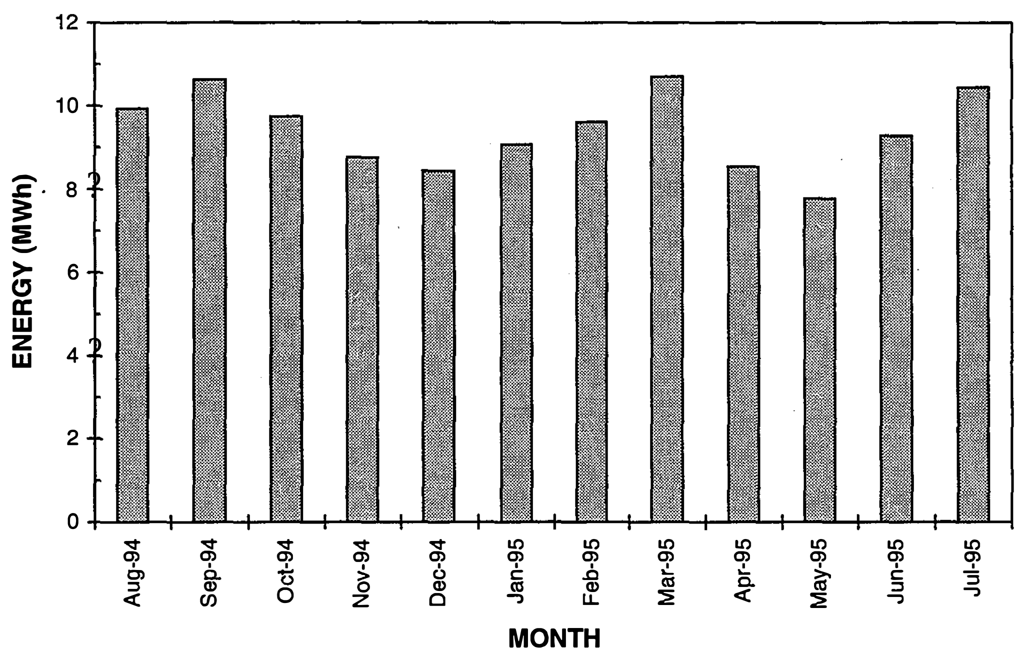

Figure 6. Monthly incident energy determined from POA irradiance and total array area.

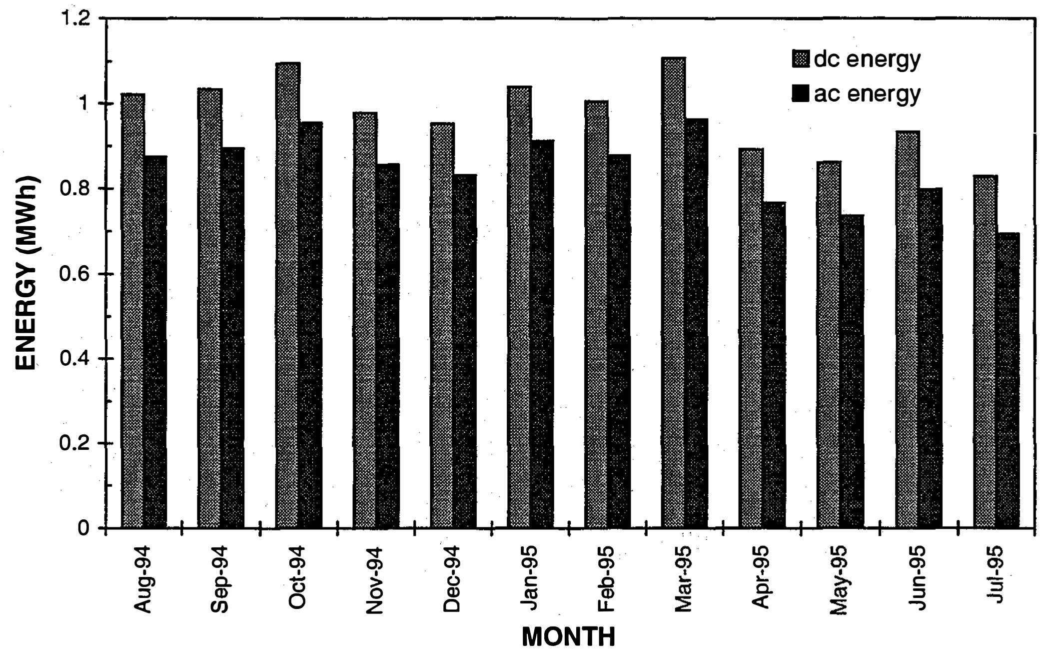

Figure 7 (a). Monthly energy produced — SERFEAST.

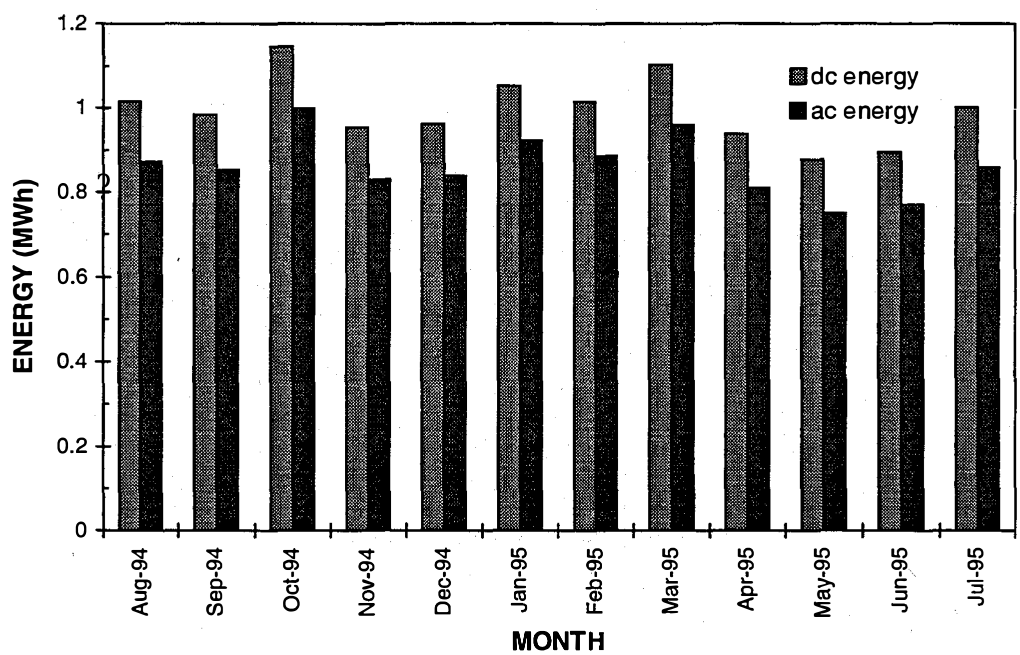

Figure 7 (b). Monthly energy produced — SERFWEST.

In addition to the above, the energy produced was compared to that predicted using a modelling program, PVFORM (Menicucci and Fernandez 1991). PVFORM uses actual radiation and meteorological data to simulate output based on system parameters and typical system losses. The radiation and meteorological data used are direct radiation, global horizontal radiation, ambient temperature, and wind speed. These data were obtained from the Reference

Meteorology and Irradiance Station (RMIS) at NREL (Myers 1995; Myers and Cannon 1995). The RMIS irradiance data is accurate to within ± 3% for global horizontal, ± 1% for direct normal, and ± 5% modeled irradiance NREL (Myers and Cannon 1995; Myers 88). Figure 8 shows the comparison of the PVFORM analysis with actual measured dc energy produced. The simulation was obtained for array losses amounting to about 16% relative to the STC dc rating. This is typical of the dc losses present (see Subsection 3.4). Furthermore, the total energy as obtained by the simulation differs from the actual SERFWEST energy produced by 1.5%, thereby indicating the significance of performing a simulation. It must be stressed, however, that by performing a simulation, many input parameters influence the ultimate output and may therefore be misleading. It must also be noted that the RMIS and SERF building are separated by a distance of approximately 600 m. This may also add to the uncertainty of the simulation results. The months where a significant difference between measured and simulated energy is observed may be attributed to either temperature effects, snow on the arrays or loss of energy production caused by the system's downtime. More specifically, the lower measured energy in September, June, and July could be attributed to temperature, while the March difference may be ascribed to snow on the arrays.

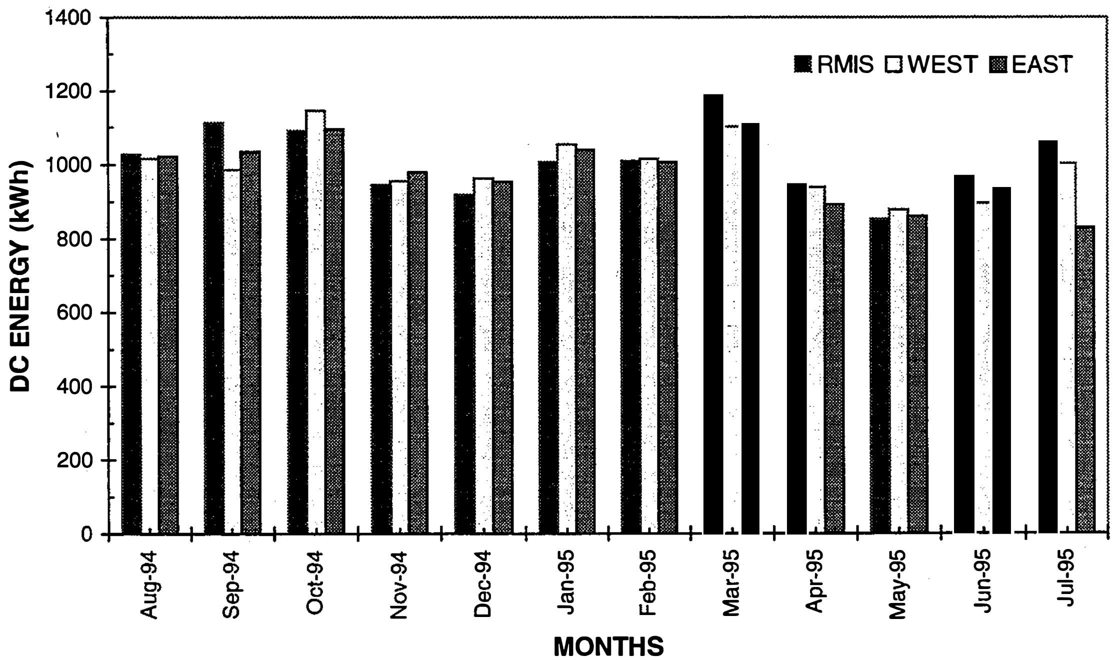

Figure 8. Comparison of simulated dc energy with actual dc energy for both systems. The simulation was performed using PVFORM and RMIS data.

The daily performance, by month, of the SERFWEST system was also determined. This was done by obtaining monthly daily averages by the hour. Figure 9 shows a comparison of the ac energy produced compared to the incident energy, based on POA irradiance and total array area, for January 1995. The back-of-module temperature is also depicted. Similar graphs for all the months of the year are shown in Appendix D together with average daily performance (by the hour) data tables for the SERFWEST system. This analysis and data tabulation serves to illustrate the daily variations in performance by the hour for each month and also gives the relevant data. It is worth noting that the array operated at about 20°C above the ambient temperature at solar noon. This is illustrated in Appendix D, Figure D.9 (m), in which the noon temperatures are compared for each month. The system's power production profile as depicted in Figures D.9 (a) through D.9 (l) can also be compared to the load profile of a utility customer. Using this information, the economics of matching output to a specific customer load profile may be considered. This type of analysis is beyond the scope of this report and is therefore not included.

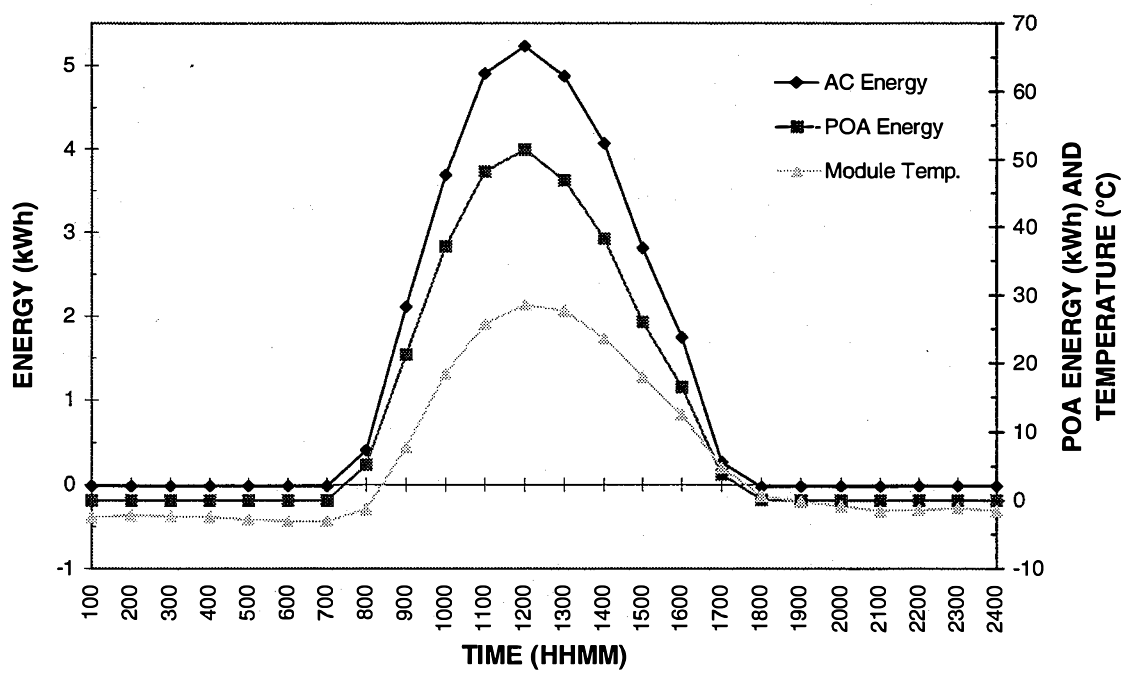

Figure 9. Comparison of hourly averages of ac energy with incident energy, as determined from POA irradiance and array area, for January 1995.

The energy produced by a system may also be used to determine capacity factor and performance index, which are useful when assessing system performance.

The capacity factor is a dimensionless factor used to determine how the system measures up to its energy rating and may be determined for any specified time period according to the following equation:

$$\text{Capacity Factor} = \frac{\text{Energy Produced (Wh)}}{\text{System Rating (W)} \times \text{time (h)}}$$

Note that time is the total number of hours for the specified period. The capacity factor is sometimes viewed as penalizing PV systems because it is sensitive to the time period chosen and to reductions in output, and is obscured by much larger insolation variations (PVUSA 1995). The capacity factor is, however, still a useful parameter that may be used to reflect system performance. The annual capacity factors, calculated using the 6-kW_{ac} PTC rating, are 19.4% and 19.7% for SERFEAST and SERFWEST systems, respectively. The monthly capacity factors are shown in Figure 10 (a).

The performance index is a parameter that accounts for effects relating to temperature, varying irradiance, soiling, degradation, balance of system (BOS) adjustments and system outages. The performance index is defined as (PVUSA 1995):

$$\text{Performance Index} = \frac{\text{Actual Generation}}{\text{Expected Generation}} = \frac{\text{Actual Generation}}{\text{Rated Power} \times \text{Adjustment Factors}}$$

The adjustment factors include irradiance normalization, temperature correction, and, if known, degradation, soiling, and BOS adjustments. For the purposes of calculating this parameter, only irradiance normalization and temperature correction (as discussed in 3.1) were used as adjustment factors. Furthermore, the performance index was calculated for all data collected for the monitoring period and the annual, as well as monthly, averages determined. The annual performance indices obtained are 82.2% and 82.7% for the SERFEAST and SERFWEST systems, respectively, and the monthly performance indices are depicted in Figure 10 (b). The unusually low performance in July 1995 (capacity factor of 15.6% and performance index of 63.9%) is prominent in Figures 10 (a) and 10 (b), and was expected, as discussed above. However, this did not greatly influence the annual performance. The relevant annual energy performance characteristics are summarized in Table 1.

Table 1. Summary of Energy Performance Characteristics.

	DC Energy (MWh)	Aperture Eff. (%)	Capacity Factor (%)	Performance Index (%)
SERFEAST	11.8	10.4	19.4	82.2
SERFWEST	12.0	10.6	19.7	82.7

It is worth noting that the capacity factors for May are the lowest, excluding July SERFEAST data. This may be attributed to snow in May, as discussed previously. The performance indices, however, show that May is a good month, which is due to the fact that the reduced irradiance in May is corrected for in determining the performance index. This may be misleading, as it could be assumed that May is a high energy-producing month, which is not the case (see

Figure 7). The performance index does, however, show that the system performed well in May under the prevailing conditions.

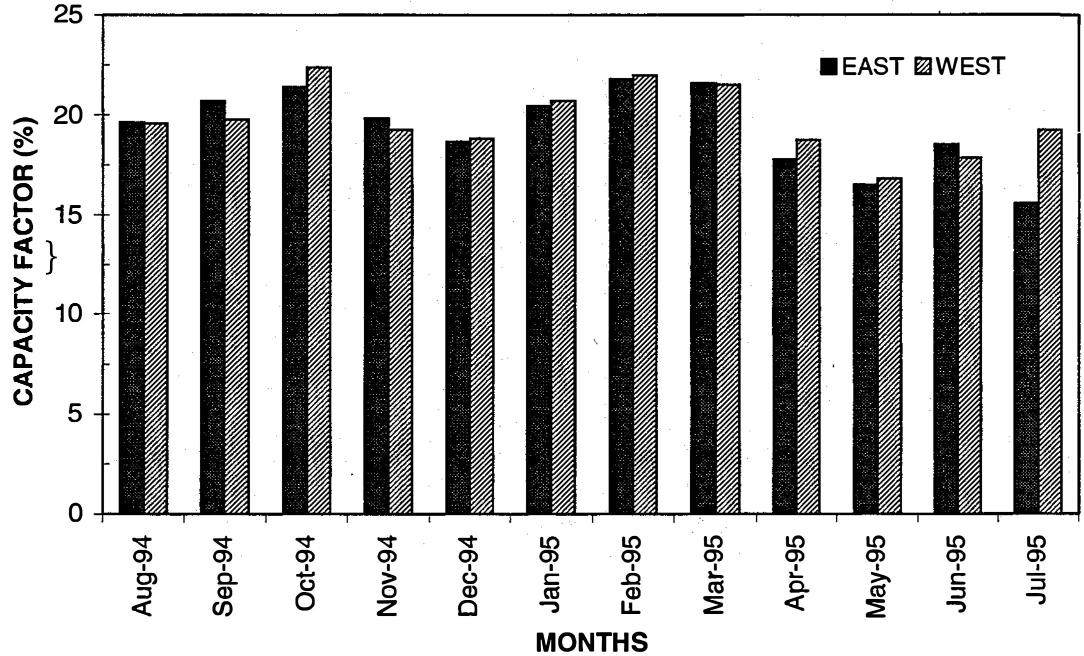

Figure 10 (a). Monthly capacity factors for both SERFEAST and SERFWEST systems.

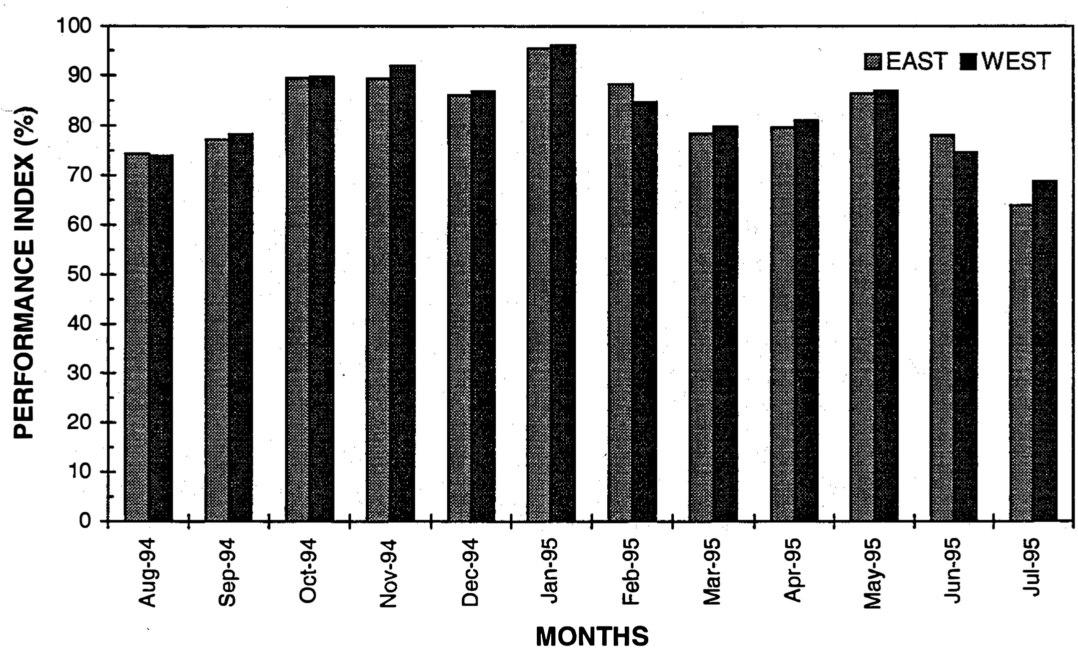

Figure 10 (b). Monthly performance indices for both SERFEAST and SERFWEST systems.

3.3 Outdoor Power Rating

Outdoor power ratings were obtained for the systems relative to STC, PTC, and Nominal Operating Cell Temperature (NOCT)[4] under conditions of the Nominal Terrestrial Environment (NTE). For these calculations the data were restricted as follows:

STC: POA irradiances > 750 W/m^2 and back-of-module temperature between 23°C and 27°C,

PTC: POA irradiances > 750 W/m^2 and ambient temperature between 18°C and 22°C, and

NOCT: POA irradiances between 750 W/m^2 and 850 W/m^2, ambient temperature between 18°C and 22°C, and wind speed between 0.8 m/s and 1.2 m/s.

The dc and ac power as a function of POA irradiance for the SERFWEST system is shown in Figures 11, 12, and 13 for STC, PTC and NOCT, respectively. The solid lines represent a least-squares fit to each data set, with the appropriate equation also shown. The corresponding graphs for the SERFEAST system are shown in Figures B.11, B.12, and B.13 in Appendix B.

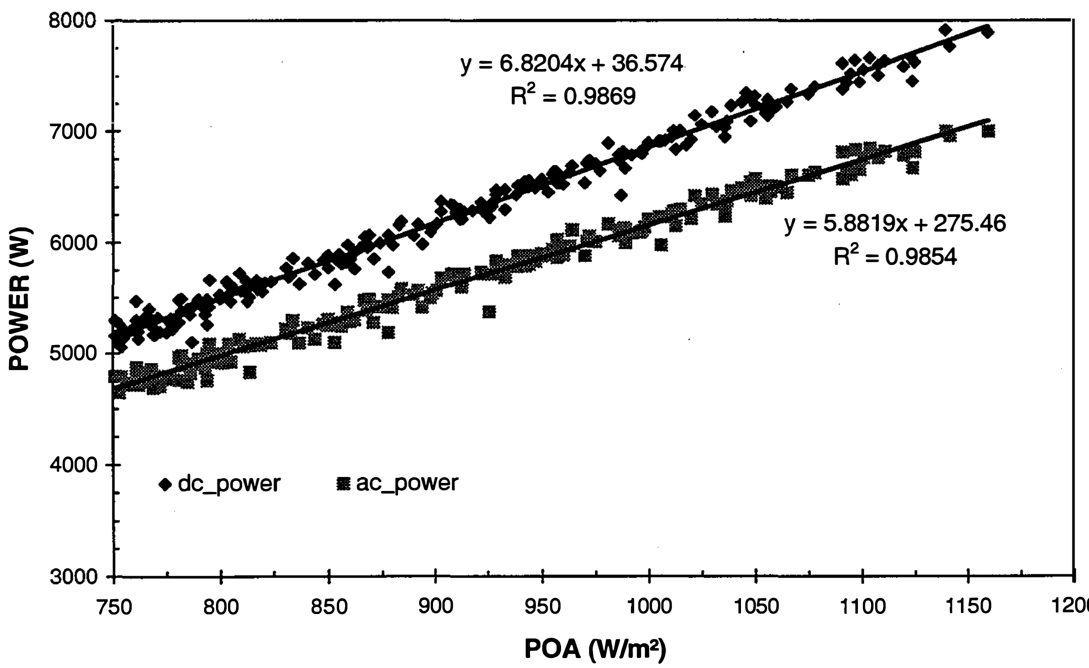

Figure 11. dc and ac power as a function of POA irradiance for STC outdoor rating.

[4] NOCT is defined as the cell temperature under the conditions of the Nominal Terrestrial Environment (NTE): 800 W/m^2 POA irradiance, 20 °C air temperature, and 1m/s wind speed.

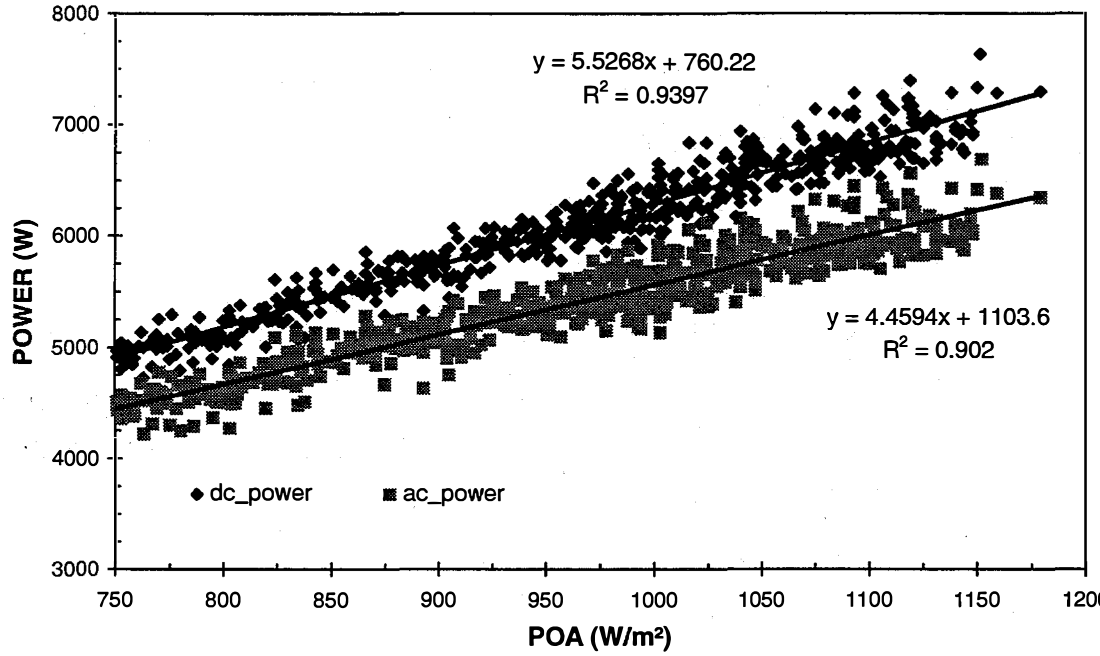

Figure 12. dc and ac power as a function of POA irradiance for PTC outdoor rating.

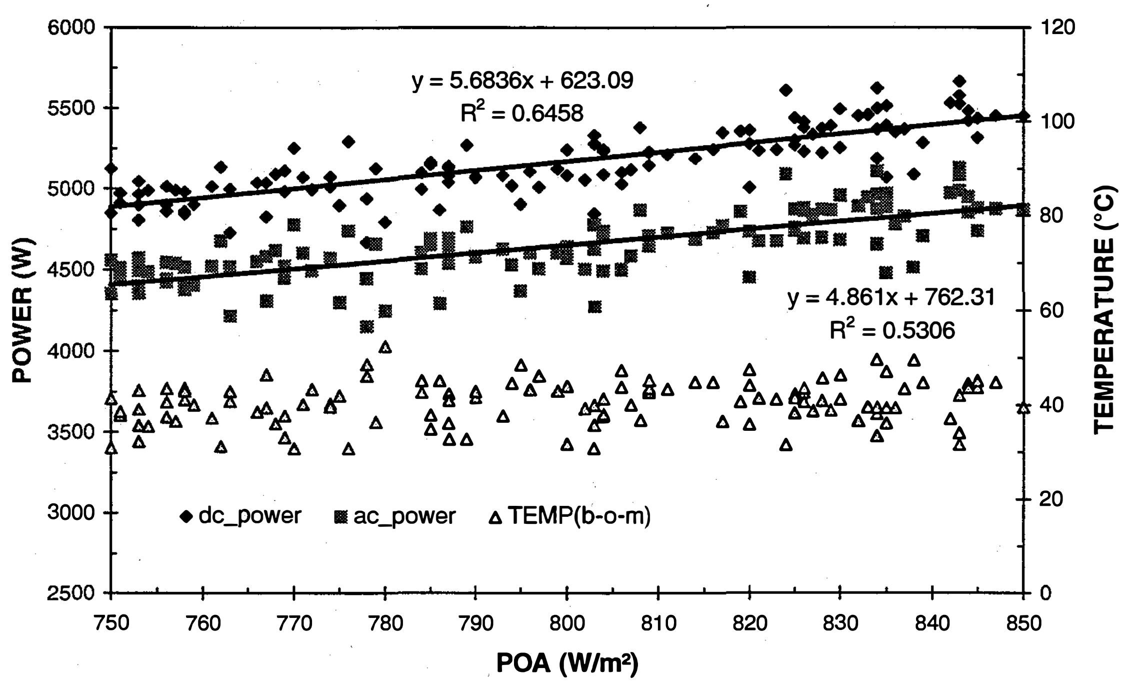

Figure 13. dc power, ac power, and back-of-module temperature as a function of POA irradiance for NOCT outdoor rating.

The data obtained for the NOCT outdoor rating calculations showed a scatter of about 5% about the least-squares fit, with the R^2 values showing weak correlation. This scatter may be attributed to the variation of cell temperature as illustrated by the variation of back-of-module temperature, also shown in Figure 13. The outdoor ratings obtained from Figures 11 to 13 for the SERFWEST system and Figures B.11 to B.13 for the SERFEAST system are summarized in Table 2.

Table 2. Outdoor rating of systems at different test conditions.

Reference Condition	DC POWER (W) East	DC POWER (W) West	AC POWER East	AC POWER West
STC	6851	6857	6140	6157
PTC	6260	6287	5509	5563
NOCT*	6408	6463	5720	5814

* Normalized to 1000 W/m^2 for comparison ?

From Table 1, it is evident that the systems do not perform as predicted. The PTC estimate of the systems is 6 kW_{ac}, and the measured outdoor ratings are lower than this by 8.2% and 7.3% for the SERFEAST and SERFWEST systems, respectively. This discrepancy may be attributed, in part, to the fact that the inverter efficiency was originally overestimated as 95%, compared to the measured value of approximately 88% (see Subsection 3.4), and also the aperture-area efficiency of the array being originally estimated at 12.8% compared to the measured value of 11.0%.

3.4 System losses

System losses, which ultimately determine system performance, may result from array losses (dc losses) and those associated with dc to ac conversion. Array losses are caused by wiring, module shadowing, soiling, degradation, reflection, and effects related to temperature and spectral variations. The array losses were determined by measurement of array characteristics and comparison with standard conditions. The array losses, measured relative to STC power rating of the arrays, are shown in Table 3. The temperature losses were calculated using the back-of-module temperature, measured at the time the array characteristics were determined, and a temperature coefficient for power of 0.4334%/°C (Kroposki 1995). The temperature losses were calculated to be as high as 13% when the modules operate at 55°C. The other losses are as discussed above. The average of these losses is 10.6%, which is not unreasonable.

Table 3. Array losses measured relative to STC.

	SERFEAST		SERFWEST	
Array Losses	Spring (%)	Summer (%)	Spring (%)	Summer (%)
Temp. Losses	5.7	12.6	6.1	11.3
Other Losses	10.5	9.2	12.6	10.2
Total Array Losses	16.2	21.8	18.8	21.5

The losses associated with dc to ac power conversion on power-conditioning equipment used are easily quantified by direct measurement of dc and ac power outputs. The losses associated with dc to ac power conversion for the SERFWEST system are illustrated in Figure 14 by the inverter efficiency and defined as the ratio P_{ac}/P_{dc}, where P_{ac} is the ac power and P_{dc} is dc power. The annual average efficiencies determined using POA irradiances above 850 W/m^2 were 88.6% and 88.3% for the SERFWEST and SERFEAST systems, respectively. This is approximately 7% below the design inverter efficiency of 95%. At 75% of full load (6 kW_{ac}), the inverter should run at 95%. It should, however, be noted that the annual inverter efficiencies based on all data collected were 86.7% and 86.4% for the SERFWEST and SERFEAST systems, respectively. The cumulative effect of all the system losses is about 30% of possible energy generation as determined by the array STC ratings of 7.43 kW per system.

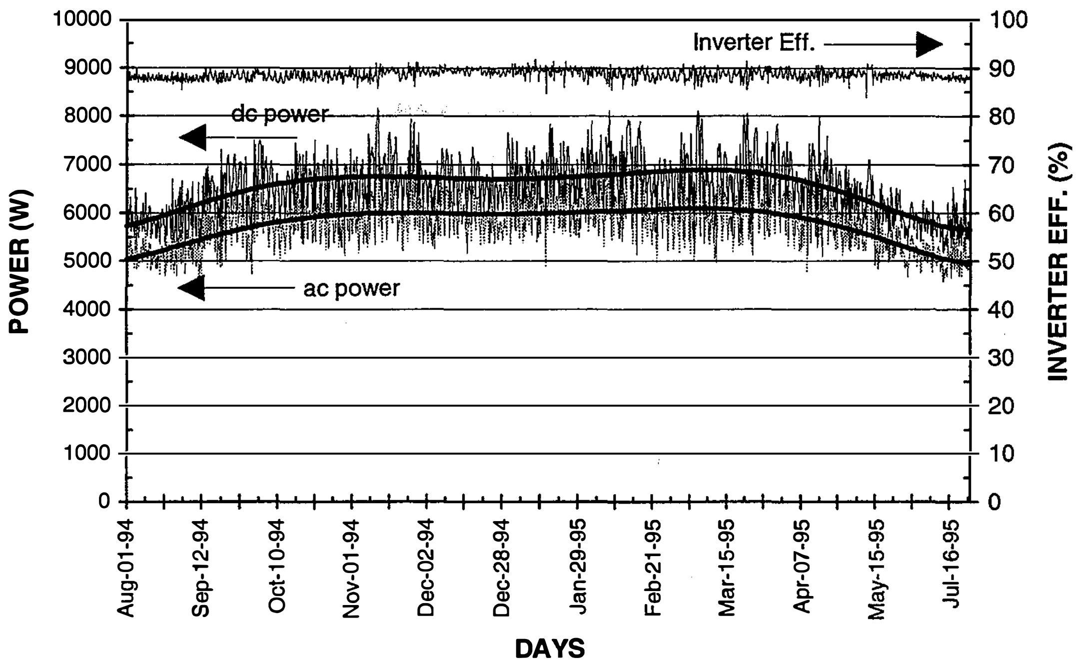

Figure 14. As-measured dc and ac power and calculated inverter efficiency for the SERFWEST system.

4 Summary and Conclusions

The data obtained from continuous system monitoring used to evaluate and compare performance of the two systems showed that the systems operated in a similar manner. The expected seasonal fluctuations for mono-crystalline Si were also observed. These seasonal variations (spring and fall maxima and corresponding winter and summer minima) are clearly illustrated by analyzing energy production data and associated parameters. The analysis of energy produced also illustrated the value of continuous monitoring to detect faulty equipment, as was the case for the peak-power tracking software. Furthermore, the energy produced was also modeled using a simulation program. This simulation, using system design parameters, yielded a total dc energy that is comparable with that measured, thereby illustrating the value of modeling system energy output. When modeling system performance, the application of system derating was found to be critical.

The analysis of system power output showed that the systems were overrated (at PTC) by approximately 7% to 8%. This may be attributed to the design inverter efficiency being estimated at 95%, compared with the measured value of approximately 87%, as well as the aperture-area efficiency being overestimated. The average measured aperture-area efficiency was 11.0%, which is significantly lower than the design value of 12.8%.

The annual average capacity factor and performance index were determined to be 19.6% and 82.5%, respectively. The performance index was, however, found to be misleading for the months with adverse weather conditions, as was the case for May 1995.

An analysis of the system losses revealed that, when excluding the effect of temperature, the average array losses amounted to 10.6% of potential energy production as measured relative to STC array rating. The temperature losses may be as high as 13% when modules operate at elevated temperatures. The annual average of dc to ac conversion losses was found to be about 13% of the generated dc power. The cumulative effect of all the system losses is about 30% of the dc array rating at STC.

Finally, the methods of analysis, as applied in this study, may be used to evaluate different systems comprising different cell technologies.

Acknowledgments

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Appendix A: Graphs of SERFWEST Performance Characteristics.

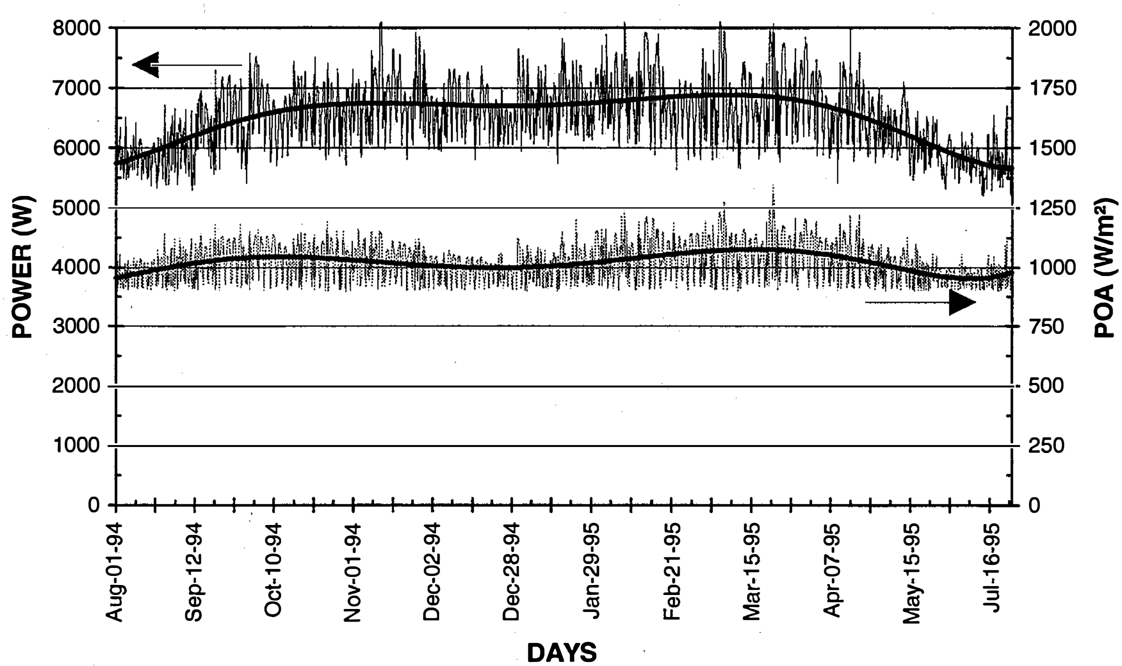

Figure A.2. Plot of as-measured dc power and POA irradiance. The solid lines are 6th-order polynomial fits for respective data sets and are included to serve as a guide to the eye.

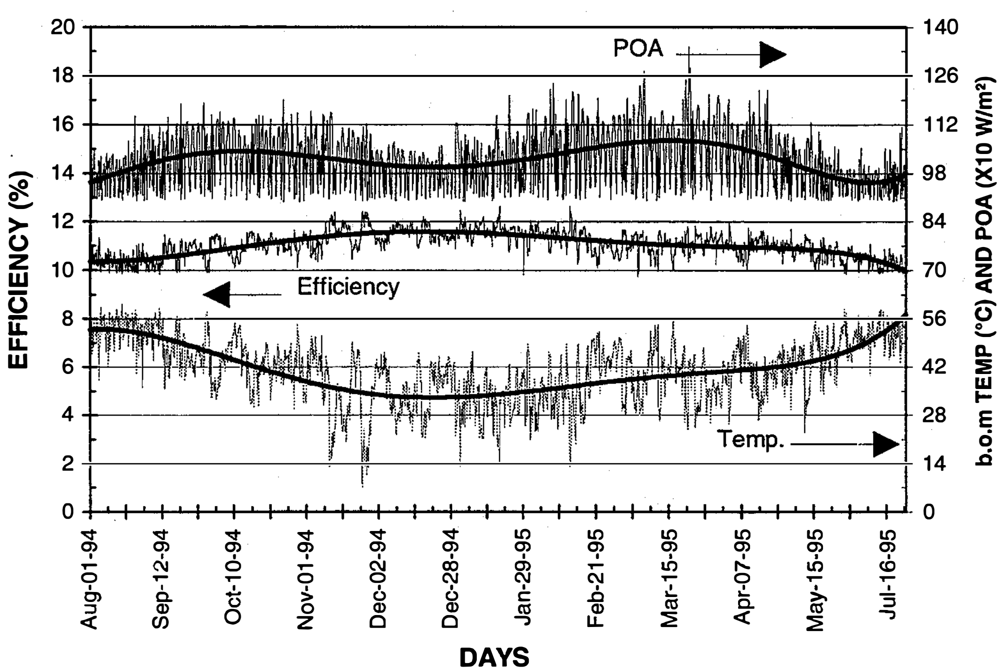

Figure A.3. Plot of aperture-area efficiency, POA irradiance, and back-of-module temperature.

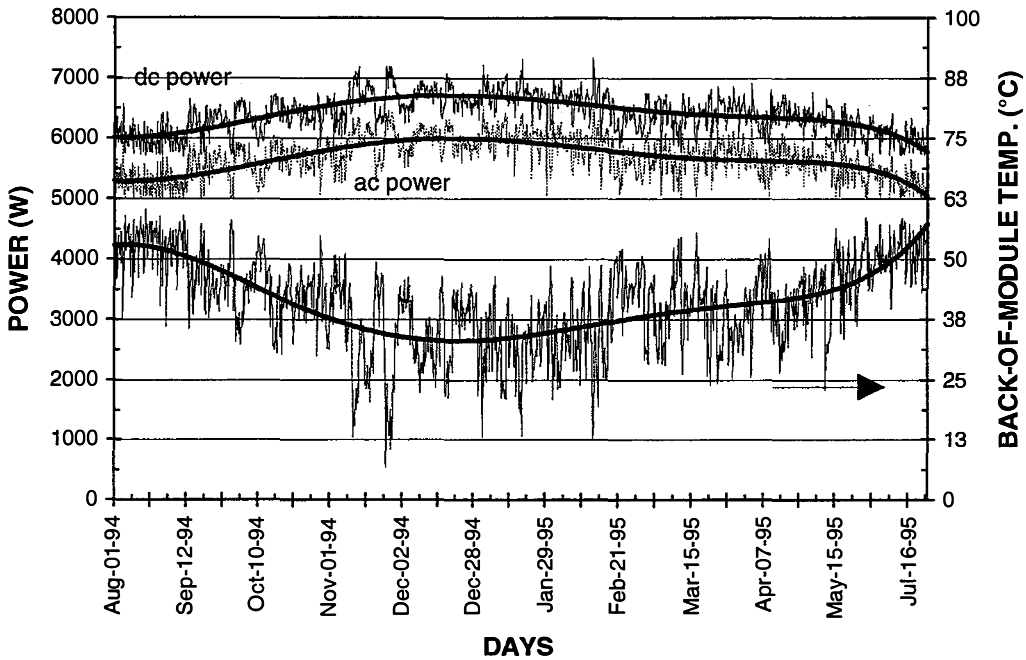

Figure A.4. Plot of normalized dc and ac power and back-of-module temperature.

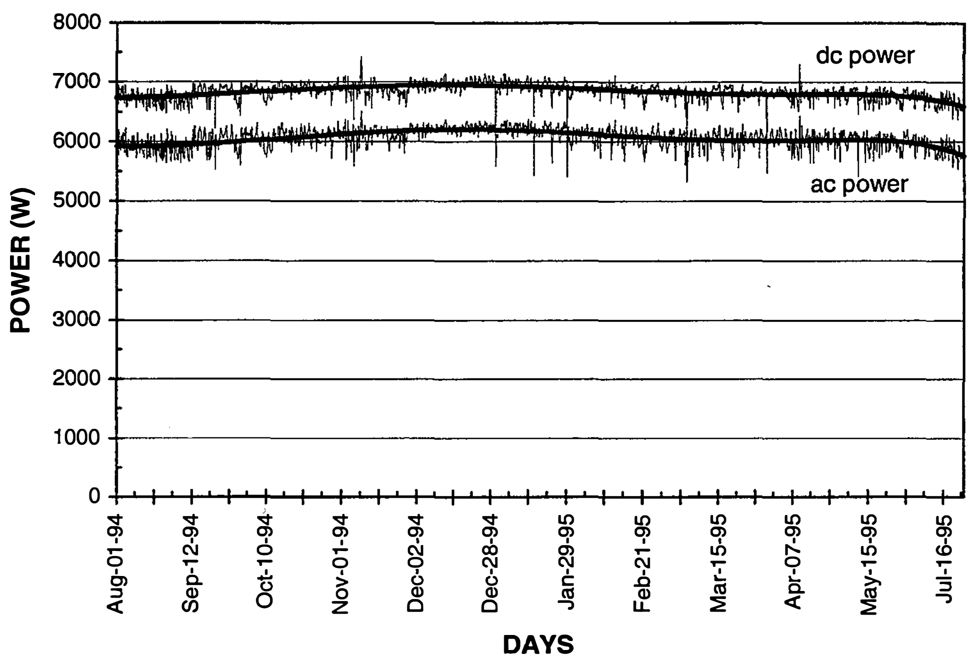

Figure A.5. Plot of normalized and temperature-corrected dc and ac power.

Appendix B: Graphs of SERFEAST Outdoor Rating and System Losses.

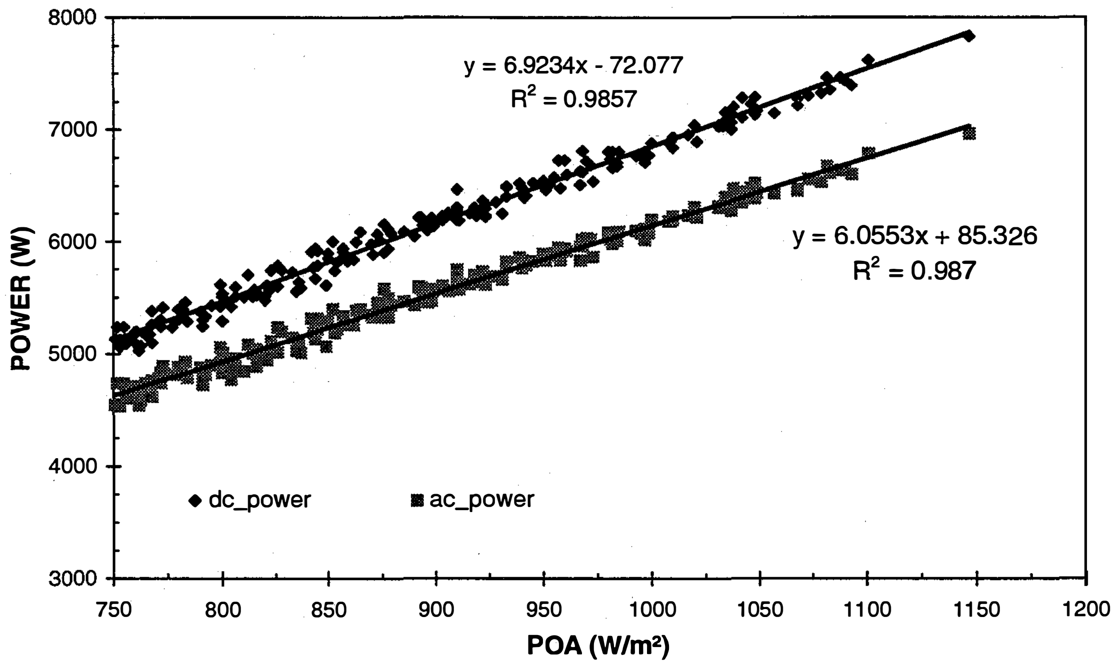

Figure B.11. dc and ac power as a function of POA irradiance for STC outdoor rating.

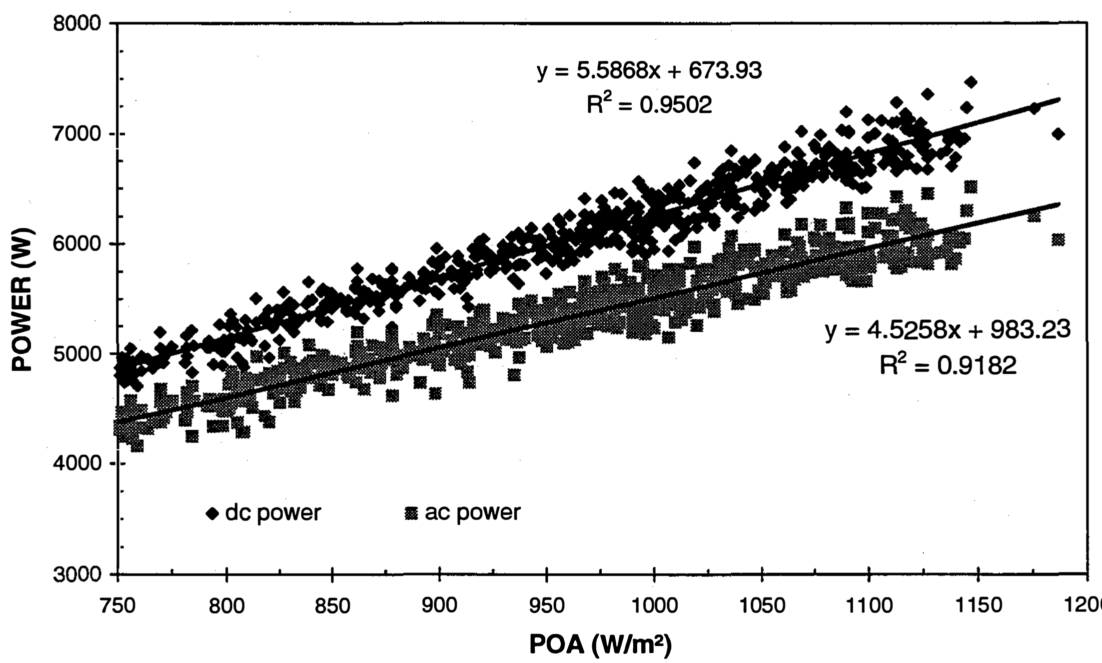

Figure B.12. dc and ac power as a function of POA irradiance for PTC outdoor rating.

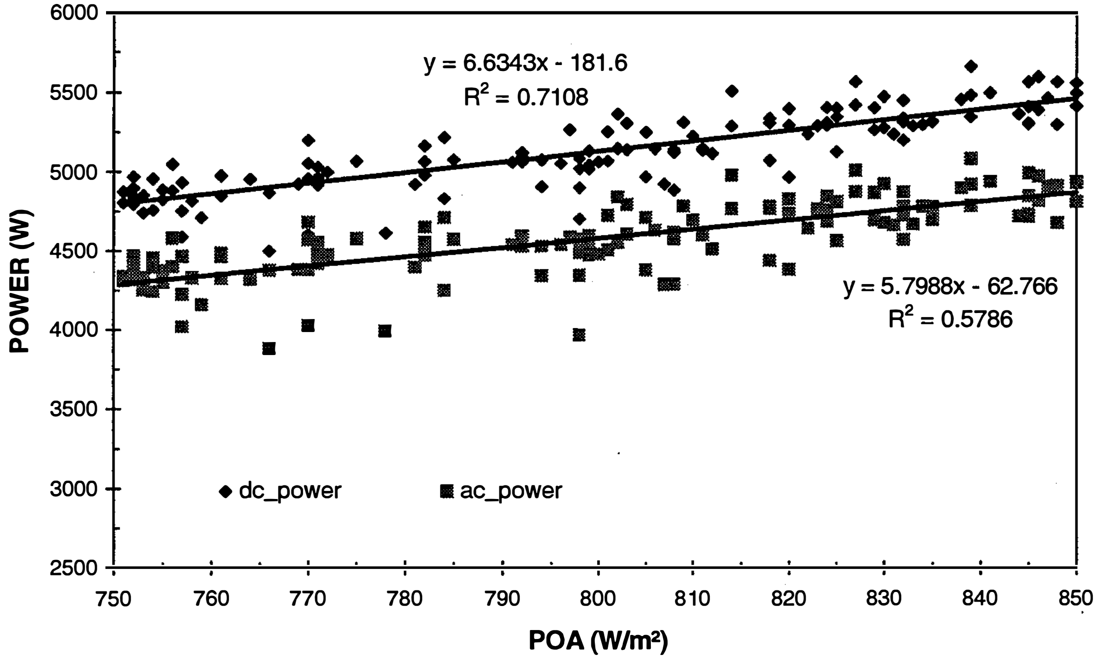

Figure B.13. dc power, ac power, and back-of-module temperature as a function of POA irradiance for NOCT outdoor rating.

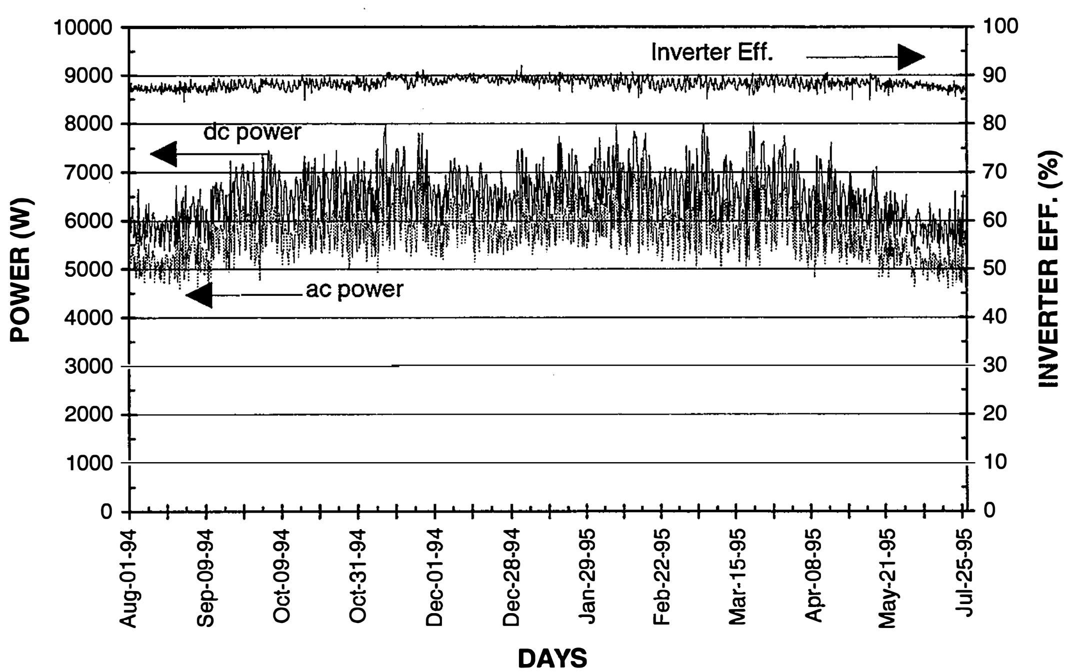

Figure B.14. As-measured dc and ac power and calculated inverter efficiency for the SERFEAST system.

Appendix C: Data Acquisition and Measurement.

Data Acquisition System (DAS)

The DAS consists of two Campbell Scientific 21X data loggers (one for each system), phone modem (one for each system), a PC computer and various measurement devices. A schematic illustrating the DAS design for the SERFEAST system is shown in Figure C.1. The SERFWEST system DAS design is identical.

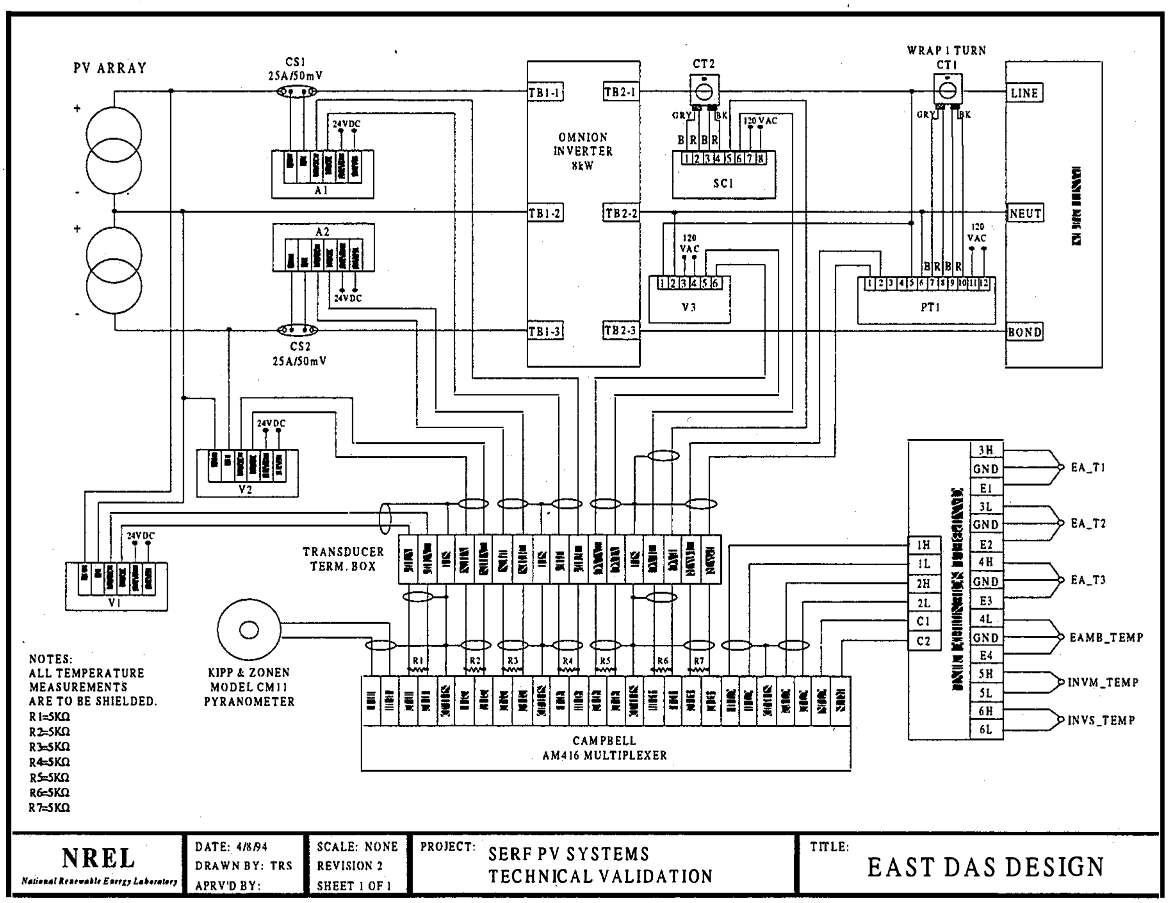

Figure C.1. DAS design of SERFEAST system.

DAS Measurements

The following measurements are made to establish and track the performance of each array and system:

Measurement	Description and Units
Plane of Array Irradiance	This measurement tracks the amount of solar radiation the array is exposed to. W/m^2
Array Current Neg. Leg	This measurement tracks the array current of the negative subarray. Amps DC
Array Current Pos. Leg	This measurement tracks the array current of the positive subarray. Amps DC
Array Voltage Neg. Leg	This measurement tracks the array voltage of the negative subarray. Volts DC
Array Voltage Pos. Leg	This measurement tracks the array voltage of the positive subarray. Volts DC
Inverter Current	This measurement tracks the AC current supplied to the utility power grid. Amps AC
Inverter Voltage	This measurement tracks the AC voltage level of the utility power grid. Volts AC
Inverter Power	This measurement tracks the AC power supplied to the utility power grid. Watts AC
Array Temp. #1	This measurement is taken from the back of one individual PV module in the PV array. °C
Array Temp. #2	This measurement is taken from the back of one individual PV module in the PV array. °C
Array Temp. #3	This measurment is taken from the back of one individual PV module in the PV array. °C
Ambient Temp.	This measurement will track the outside ambient temperature. °C
Inverter Enclosure Temp.	This measurement monitors the operating temperature inside the master OMNION. °C
Inverter Enclosure Temp.	This measurement monitors the operating temperature inside the slave OMNION. °C
Meteorological data	Using the existing weather stations, weather conditions are tracked.

Irradiance measurements are zeroed (via software filters) when POA irradiance is less than 1 W/m^2. All efficiency measurements are zeroed when POA irradiance is less than 100 W/m^2. All DC measurements are zeroed when array positive leg voltages are less than 192 VDC. The previous list of measurements is stored along with station ID (ID=006 West Array/ID=007 East Array), year, Julian day, time stamp, and various calculated results in the following element assignments (see below/next page), excluding meteorological data. All data, with the exception of elements 22 through 27, are either measured or calculated once every 5 seconds. The result is then averaged over a 15-minute time interval.

Element	Definition	Units
1	DAS ID	006/007
2	Year	YYYY
3	Julian Day	DDD
4	TIME	HHMM
5	Avg. Array Power	Watts DC
6	Avg. Inverter Power	Watts AC
7	Avg. Plane of Array Irradiance	W/m^2
8	Avg. DC Volts Pos. Leg	Volts DC
9	Avg. DC Volts Neg. Leg	Volts DC
10	Avg. DC Amperes Pos. Leg	Amp DC
11	Avg. DC Amperes Neg. Leg	Amp DC
12	Avg. AC Volts	Volts AC
13	Avg. AC Amperes	Amp AC
14	Avg. Array Temp. #1	^0C
15	Avg. Array Temp. #2	^0C
16	Avg. Array Temp. #3	^0C
17	Avg. Ambient Temperature	^0C
18	Avg. Inverter Temp. (master)	^0C
19	Avg. Inverter Temp. (slave)	^0C
20	Avg. Array Efficiency	%
21	Avg. Inverter Efficiency	%
22	Daily Accumulative DC Energy	kWh DC
23	Daily Accumulative AC Energy	kWh AC
24	Daily Accumulative POA Irradiance	kWh/m^2

Element	Definition	Units
25	Accumulative DC Energy	MWh DC
26	Accumulative AC Energy	MWh AC
27	Accumulative POA Irradiance	MWh/m^2

Note: Elements 22 through 27 are updated every 15 minutes. Elements 5 and 20 through 27 are calculated as follows:

Element 5:
Array Power = (DCV Pos. Leg * DCA Pos. Leg) + (DCV Neg. Leg * DCA Neg. Leg)
Element 20:
Array efficiency = [(Array Power (element 5)) / (POA Irrad. (element 7) * Total Aperture Area)]*100
where: Total Aperture area = (140 modules * 4025.7 cm^2) = 56.3598 m^2
Element 21:
Inverter efficiency = [(Inverter Power (element 6)) / (Array Power (element 5))] * 100
Element 22:
Daily Accumulative DC Energy = Daily Σ Array Power (element 5)/4/1,000
Element 23:
Daily Accumulative AC Energy = Daily Σ Inverter Power (element 6)/4/1,000
Element 24:
Daily Accumulative POA Irradiance = Daily Σ POA Irrad. (element 7)/4/1,000
Element 25:
Accumulative DC Energy = Σ Array Power (element 5)/4/1,000,000
Element 26:
Accumulative AC Energy = Σ Inverter Power (element 6)/4/1,000,000
Element 27:
Accumulative POA Irradiance = Σ POA Irrad. (element 7)/4/1,000,000

Appendix D: Monthly Average Daily Performance by Hour.

					SERFWEST SYSTEM								
					AVERAGE DAILY PERFORMANCE BY HOUR FOR AUGUST, 1994								
				ARRAY V	ARRAY V	ARRAY I	ARRAY I			ARRAY	AMBIENT	ARRAY	INVERTER
TIME	DC ENERGY	AC ENERGY	INSOL	POS	NEG	POS	NEG	INVV	INV I	TEMP	TEMP	EFF	EFF
HHMM	kWh	kWh	kWh	Vdc	Vdc	A	A	Vac	A	DEG C	DEG C	%	%
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.5	5.2	17.4	19.7	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.6	5.2	17.3	19.5	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.6	5.2	17.0	19.3	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.4	5.2	16.6	18.8	0.0	0.0
500	0.00	-0.02	0.00	0.8	-0.8	0.0	0.0	119.1	5.2	16.2	18.4	0.0	0.0
600	0.11	0.00	1.62	175.9	-176.5	0.3	-0.2	118.3	5.8	16.3	18.2	3.7	12.3
700	0.71	0.48	10.67	250.9	-251.5	1.5	-1.4	118.8	8.1	21.5	19.4	7.4	64.9
800	2.01	1.72	23.47	242.1	-243.4	4.4	-4.3	122.4	16.4	31.0	21.5	8.8	85.0
900	3.93	3.52	36.19	224.9	-227.6	8.8	-8.8	122.8	28.9	40.4	23.7	11.0	89.7
1000	4.94	4.39	46.28	219.1	-222.4	11.2	-11.2	122.9	34.7	47.8	25.8	11.1	88.9
1100	5.13	4.51	49.71	219.0	-222.3	11.6	-11.7	122.9	35.4	51.4	27.3	10.8	88.0
1200	4.29	3.76	41.41	218.8	-221.5	9.7	-9.8	122.8	30.1	47.3	27.6	11.1	87.7
1300	3.58	3.14	34.19	221.1	-223.4	8.1	-8.1	122.6	25.6	44.5	27.7	11.0	87.7
1400	3.01	2.64	28.49	221.1	-223.1	6.8	-6.8	122.5	22.2	40.5	27.4	11.2	87.8
1500	2.35	2.08	21.47	221.3	-223.1	5.3	-5.3	122.4	18.1	36.9	27.1	11.4	88.2
1600	1.48	1.28	13.51	221.2	-222.4	3.3	-3.3	122.3	12.7	31.8	26.5	10.9	86.2
1700	0.86	0.69	8.61	217.5	-218.3	2.0	-1.9	122.5	8.9	28.3	25.6	10.0	79.2
1800	0.34	0.20	3.45	212.2	-212.8	0.8	-0.8	122.9	6.4	24.8	24.7	9.6	54.7
1900	0.07	-0.03	0.85	161.7	-162.3	0.2	-0.2	122.9	5.7	21.8	23.2	3.7	3.5
2000	0.00	-0.02	0.01	3.8	-3.8	0.0	0.0	123.1	5.2	19.9	22.1	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	121.9	5.2	19.2	21.3	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.1	5.1	18.4	20.5	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.3	5.1	18.0	20.2	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.4	5.2	17.7	19.9	0.0	0.0

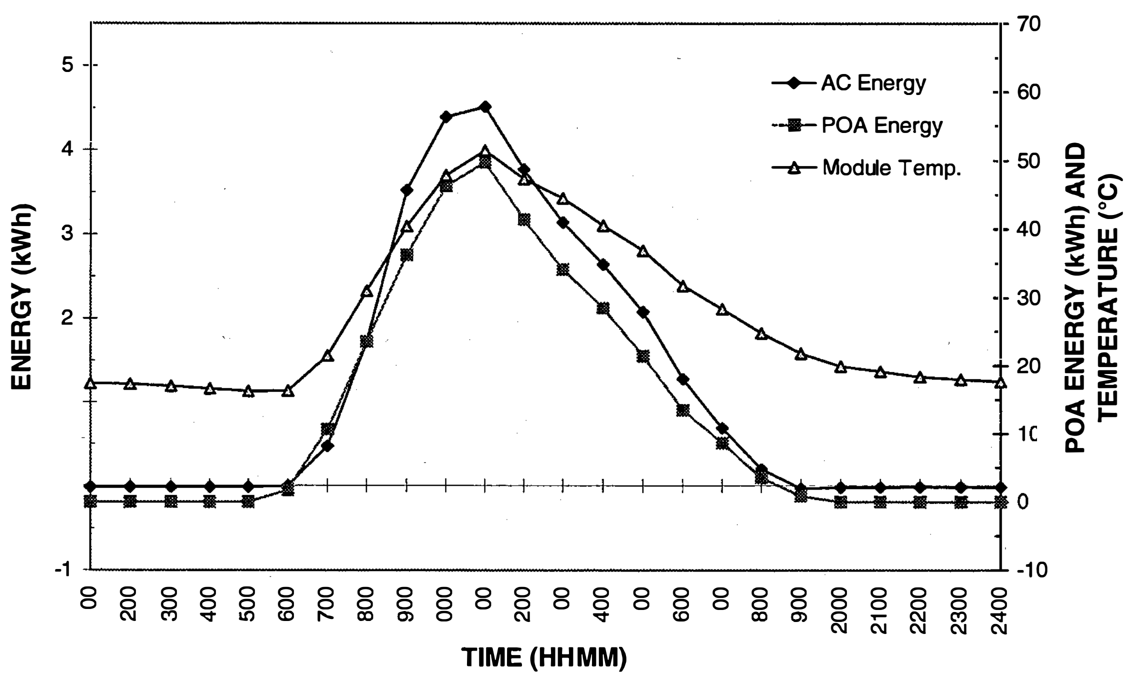

Figure D.9 (a). August 1994.

Note that the column "INSOL" is incident energy based on POA irradiance and array area.

SERFWEST SYSTEM

AVERAGE DAILY PERFORMANCE BY HOUR FOR SEPTEMBER, 1994

TIME	DC ENERGY kWh	AC ENERGY kWh	INSOL kWh	ARRAY V POS Vdc	ARRAY V NEG Vdc	ARRAY I POS A	ARRAY I NEG A	INV V Vac	INV I A	ARRAY TEMP DEG C	AMBIENT TEMP DEG C	ARRAY EFF %	INVERTER EFF %
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	107.8	4.7	13.5	15.9	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	108.1	4.7	13.4	15.7	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	108.1	4.7	13.2	15.6	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	107.9	4.7	13.3	15.5	0.0	0.0
500	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	107.8	4.7	12.7	15.1	0.0	0.0
600	0.03	-0.02	0.47	70.1	-70.4	0.1	-0.1	107.4	4.9	12.4	14.7	0.9	0.0
700	0.71	0.53	9.10	235.3	-235.9	1.5	-1.5	106.1	8.0	16.4	15.7	7.1	68.9
800	2.10	1.84	22.74	237.4	-238.7	4.6	-4.6	109.7	17.0	25.9	17.8	9.4	87.6
900	3.55	3.17	36.74	231.0	-233.4	7.9	-7.9	114.0	26.8	36.7	20.2	10.0	89.3
1000	4.47	3.95	46.94	228.6	-231.6	10.0	-10.1	112.0	32.3	44.0	21.9	9.9	88.5
1100	4.82	4.22	51.88	227.2	-230.1	10.8	-10.9	112.1	33.9	46.8	22.9	9.9	87.6
1200	4.47	3.91	49.55	227.5	-230.1	10.0	-10.1	111.9	31.5	46.9	23.7	9.7	87.4
1300	4.17	3.66	45.65	225.3	-227.7	9.4	-9.4	111.8	29.6	46.0	24.3	10.0	87.9
1400	3.44	3.05	36.52	226.4	-228.6	7.7	-7.7	111.6	25.1	40.8	24.0	10.3	88.7
1500	2.66	2.38	27.56	227.6	-229.4	5.9	-6.0	111.3	20.2	36.5	23.9	10.5	89.5
1600	1.69	1.48	17.72	228.3	-229.7	3.8	-3.8	111.2	13.9	31.2	23.6	10.1	87.7
1700	0.63	0.48	7.68	222.4	-223.0	1.4	-1.4	111.3	7.4	24.7	22.5	8.7	73.6
1800	0.12	0.01	1.46	194.5	-195.1	0.3	-0.3	111.6	5.4	19.6	20.9	5.7	15.0
1900	0.00	-0.03	0.06	28.9	-29.1	0.0	0.0	111.6	4.8	16.6	19.0	0.2	0.0
2000	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	109.6	4.7	15.4	17.9	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	107.8	4.7	14.6	17.3	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	107.9	4.7	14.3	16.8	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	108.0	4.7	14.1	16.5	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	107.8	4.7	13.7	16.1	0.0	0.0

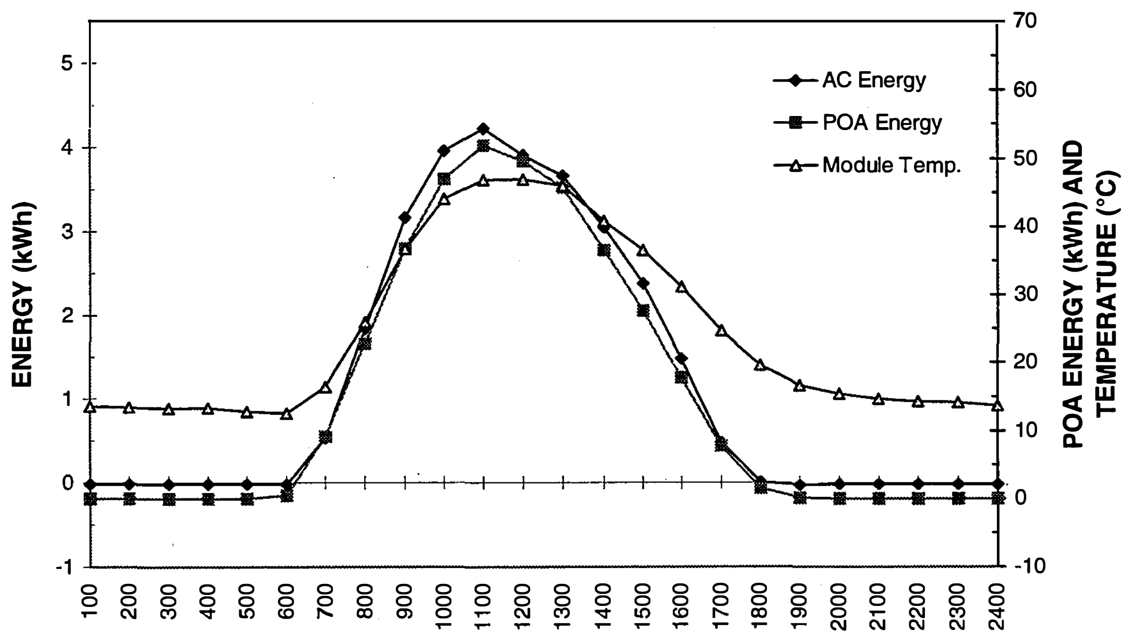

Figure D.9 (b). September 1994.

SERFWEST SYSTEM

AVERAGE DAILY PERFORMANCE BY HOUR FOR OCTOBER, 1994

TIME	DC ENERGY kWh	AC ENERGY kWh	INSOL kWh	ARRAY V POS Vdc	ARRAY V NEG Vdc	ARRAY I POS A	ARRAY I NEG A	INV V Vac	INV I A	ARRAY TEMP DEG C	AMBIENT TEMP DEG C	ARRAY EFF %	INVERTER EFF %
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.5	5.5	5.6	8.2	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.6	5.5	5.7	8.1	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.6	5.5	5.3	7.8	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.3	5.5	5.1	7.7	0.0	0.0
500	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.1	5.5	4.7	7.4	0.0	0.0
600	0.00	-0.02	0.01	5.2	-5.2	0.0	0.0	123.5	5.5	4.4	7.1	0.0	0.0
700	0.58	0.42	5.21	196.5	-197.4	1.2	-1.2	123.4	8.4	6.2	7.3	7.0	50.9
800	2.54	2.24	21.49	234.7	-236.6	5.4	-5.3	123.0	20.5	16.3	9.3	11.4	87.9
900	3.80	3.39	33.07	228.9	-231.6	8.3	-8.3	123.0	29.5	26.1	11.3	11.7	89.2
1000	4.92	4.35	43.67	226.2	-229.6	10.9	-10.9	124.4	36.7	32.5	12.9	11.6	88.5
1100	5.52	4.86	49.71	225.1	-228.8	12.2	-12.3	124.5	40.2	35.9	14.1	11.6	88.0
1200	5.38	4.73	48.44	224.8	-228.2	11.9	-12.0	124.5	38.9	36.0	15.0	11.7	88.0
1300	4.92	4.35	43.83	225.0	-228.0	10.9	-11.0	124.3	35.8	34.8	15.5	11.9	88.5
1400	3.90	3.48	34.04	225.7	-228.3	8.6	-8.7	124.0	29.2	31.0	15.6	12.0	89.3
1500	3.06	2.74	26.25	228.0	-230.1	6.7	-6.7	123.8	23.6	26.7	15.7	12.1	89.6
1600	1.84	1.61	16.15	229.8	-231.2	4.0	-4.0	123.6	15.3	21.1	15.1	11.7	86.9
1700	0.49	0.33	5.14	215.0	-215.8	1.1	-1.1	123.4	7.5	14.6	14.0	8.6	51.2
1800	0.01	-0.05	0.13	67.1	-67.4	0.0	0.0	123.4	5.6	9.9	12.3	0.5	0.0
1900	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.5	5.4	8.6	11.3	0.0	0.0
2000	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.8	5.4	7.8	10.5	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.0	5.5	7.4	9.9	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.2	5.5	6.7	9.3	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.3	5.5	6.4	8.9	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.4	5.5	5.9	8.5	0.0	0.0

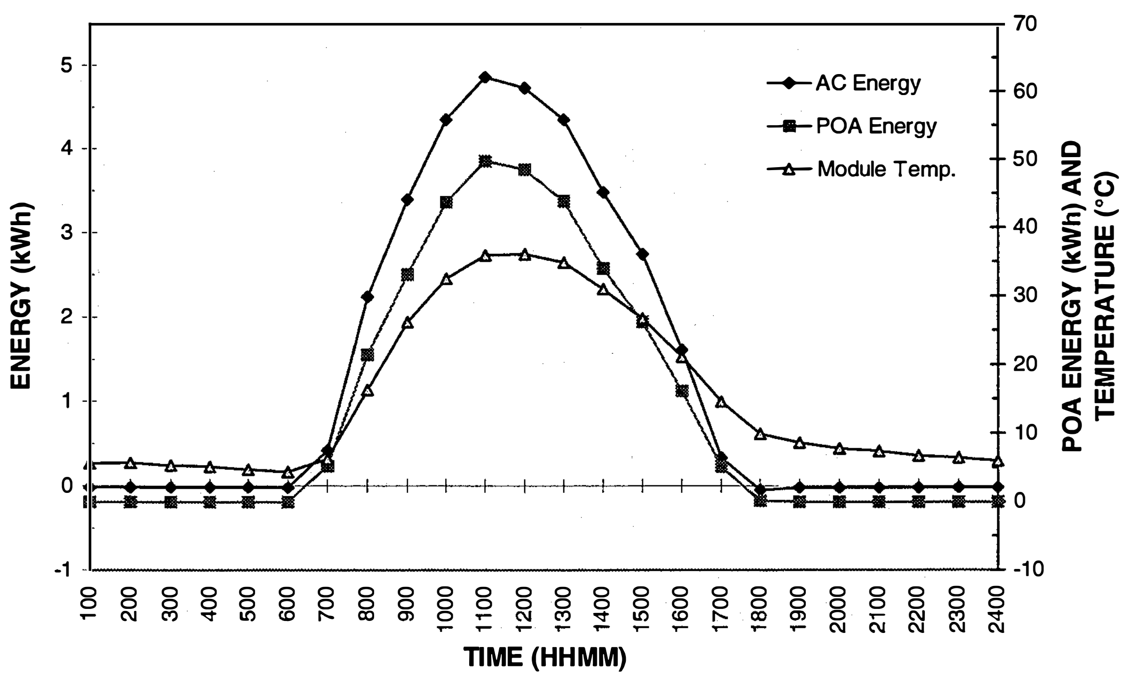

Figure D.9 (c). October 1994.

SERFWEST SYSTEM

AVERAGE DAILY PERFORMANCE BY HOUR FOR NOVEMBER, 1994

TIME	DC ENERGY kWh	AC ENERGY kWh	INSOL kWh	ARRAY V POS Vdc	ARRAY V NEG Vdc	ARRAY I POS A	ARRAY I NEG A	INV V Vac	INV I A	ARRAY TEMP DEG C	AMBIENT TEMP DEG C	ARRAY EFF %	INVERTER EFF %
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.9	5.5	-0.1	2.1	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.0	5.5	-0.7	1.7	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.1	5.5	-0.6	1.8	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	124.0	5.5	-0.5	1.6	0.0	0.0
500	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.8	5.5	-0.8	1.5	0.0	0.0
600	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.7	5.5	-1.4	0.8	0.0	0.0
700	0.06	0.00	0.62	73.1	-73.4	0.1	-0.1	123.2	5.9	-1.6	0.4	1.3	10.5
800	1.33	1.11	11.33	215.8	-218.1	2.7	-2.8	123.0	12.8	3.6	1.2	10.0	81.4
900	3.04	2.69	26.15	228.1	-231.6	6.3	-6.4	123.2	24.3	13.1	3.2	10.9	88.4
1000	4.42	3.94	38.77	227.5	-230.8	9.5	-9.6	123.5	34.2	21.3	4.6	11.0	89.1
1100	4.83	4.26	42.97	228.4	-232.1	10.4	-10.5	123.6	36.7	24.6	5.9	11.0	88.2
1200	4.89	4.31	43.43	228.6	-231.9	10.6	-10.7	123.6	36.8	26.3	6.6	11.3	88.2
1300	4.68	4.16	41.98	228.1	-231.0	10.2	-10.2	123.6	35.4	26.1	7.1	11.3	89.0
1400	4.03	3.61	35.25	229.5	-231.9	8.7	-8.7	123.4	30.9	23.5	7.1	11.6	89.5
1500	2.97	2.65	24.86	234.2	-236.2	6.3	-6.3	123.1	23.4	18.6	7.0	11.7	89.1
1600	1.40	1.18	11.96	226.3	-227.5	2.9	-2.9	122.6	12.8	11.4	6.4	11.0	83.8
1700	0.16	0.05	1.66	165.2	-165.9	0.4	-0.4	122.4	6.4	4.0	4.8	4.7	17.9
1800	0.00	-0.02	0.00	0.3	-0.3	0.0	0.0	122.8	5.4	0.9	3.3	0.0	0.0
1900	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.0	5.5	0.3	2.8	0.0	0.0
2000	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.2	5.5	0.3	2.6	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.3	5.5	0.2	2.6	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.5	5.5	0.2	2.3	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.7	5.5	0.0	2.2	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.8	5.5	0.0	2.1	0.0	0.0

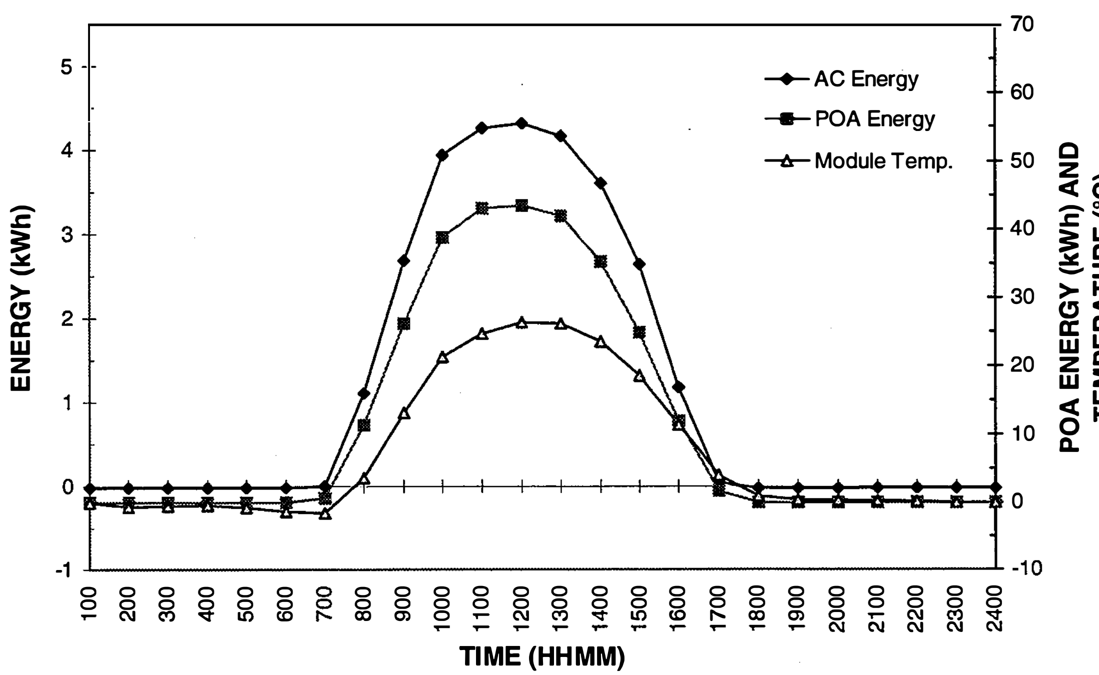

Figure D.9 (d). November 1994.

					SERFWEST SYSTEM								
					AVERAGE DAILY PERFORMANCE BY HOUR FOR DECEMBER, 1994								
				ARRAY V	ARRAY V	ARRAY I	ARRAY I			ARRAY	AMBIENT	ARRAY	INVERTER
TIME	DC ENERGY	AC ENERGY	INSOL	POS	NEG	POS	NEG	INVV	INV I	TEMP	TEMP	EFF	EFF
	kWh	kWh	kWh	Vdc	Vdc	A	A	Vac	A	DEG C	DEG C	%	%
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.7	5.6	-0.7	1.7	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.7	5.6	-0.8	1.6	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.7	5.6	-0.9	1.3	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	120.2	5.4	-1.5	0.9	0.0	0.0
500	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.5	5.4	-1.6	0.8	0.0	0.0
600	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.4	5.4	-1.7	0.6	0.0	0.0
700	0.00	-0.02	0.00	5.7	-5.7	0.0	0.0	119.0	5.4	-2.2	0.2	0.0	0.0
800	0.72	0.55	6.66	202.9	-203.9	1.5	-1.5	118.9	9.2	0.4	0.5	6.5	55.7
900	2.70	2.38	23.95	238.4	-240.4	5.6	-5.6	119.9	21.8	11.9	3.0	10.9	87.9
1000	3.99	3.54	34.92	228.9	-232.1	8.6	-8.7	123.2	31.2	21.2	5.1	11.2	88.7
1100	4.78	4.23	42.41	225.2	-228.6	10.5	-10.5	123.4	36.4	26.4	6.4	11.0	88.5
1200	5.01	4.44	43.85	224.0	-227.3	11.1	-11.1	123.6	37.7	27.6	7.4	11.1	88.5
1300	4.84	4.31	43.24	225.0	-228.0	10.7	-10.6	123.5	36.5	26.8	8.1	11.1	89.1
1400	4.30	3.86	37.66	227.2	-229.9	9.4	-9.3	123.3	32.8	24.1	8.1	11.2	89.8
1500	3.04	2.71	25.89	231.2	-233.2	6.4	-6.4	123.0	24.0	18.5	7.7	11.4	89.4
1600	1.53	1.31	13.08	231.7	-232.9	3.2	-3.2	122.6	13.7	11.5	6.7	11.1	84.7
1700	0.14	0.03	1.38	159.8	-160.4	0.3	-0.3	122.3	6.3	3.6	4.7	4.2	16.7
1800	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.5	5.5	0.6	3.0	0.0	0.0
1900	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.2	5.5	-0.3	2.2	0.0	0.0
2000	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.3	5.5	-0.5	1.8	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.4	5.5	-0.8	1.5	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.5	5.5	-1.1	1.3	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.6	5.5	-1.2	1.1	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	123.6	5.5	-1.4	0.9	0.0	0.0

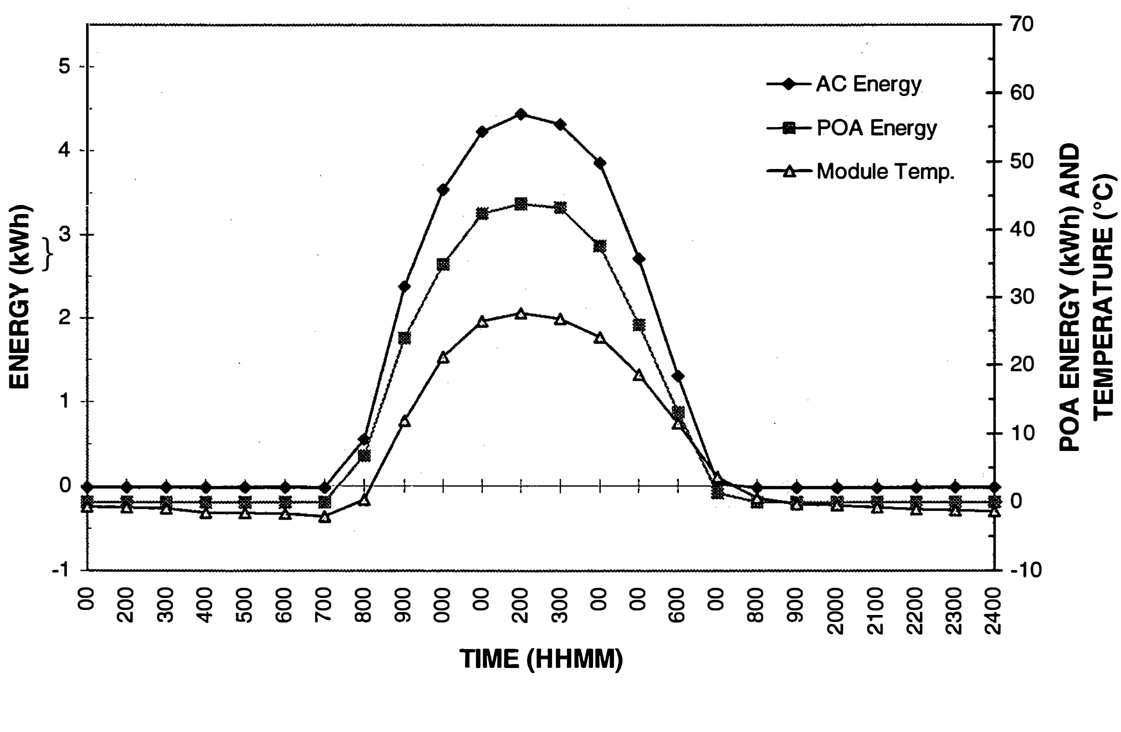

Figure D.9 (e). December 1994.

SERFWEST SYSTEM

AVERAGE DAILY PERFORMANCE BY HOUR FOR JANUARY, 1995

TIME	DC ENERGY kWh	AC ENERGY kWh	INSOL kWh	ARRAY V POS Vdc	ARRAY V NEG Vdc	ARRAY I POS A	ARRAY I NEG A	INV V Vac	INV I A	ARRAY TEMP DEG C	AMBIENT TEMP DEG C	ARRAY EFF %	INVERTER EFF %
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.0	5.4	-2.4	-0.3	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.0	5.4	-2.2	-0.2	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.0	5.4	-2.4	-0.3	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.0	5.4	-2.4	-0.4	0.0	0.0
500	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.7	5.3	-2.9	-0.7	0.0	0.0
600	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.7	5.3	-3.0	-0.8	0.0	0.0
700	0.00	-0.02	0.00	0.3	-0.4	0.0	0.0	118.4	5.3	-3.1	-0.8	0.0	0.0
800	0.55	0.41	5.16	185.8	-186.8	1.1	-1.1	118.3	8.3	-1.3	-0.5	5.9	49.3
900	2.41	2.11	21.24	239.2	-241.2	4.9	-4.9	118.4	19.7	7.7	1.3	11.0	87.5
1000	4.14	3.69	37.14	238.7	-241.2	8.8	-8.8	119.8	31.7	18.6	3.5	11.3	89.1
1100	5.49	4.90	48.19	230.7	-233.6	11.9	-11.9	122.9	40.9	25.8	5.0	11.7	89.3
1200	5.86	5.23	51.49	229.3	-233.0	12.8	-12.8	123.0	43.0	28.6	6.3	11.9	89.2
1300	5.45	4.87	46.96	229.1	-232.5	11.9	-11.9	122.9	39.9	27.7	6.7	12.1	89.5
1400	4.54	4.07	38.25	231.2	-234.0	9.8	-9.8	122.7	33.7	23.6	6.5	12.4	89.6
1500	3.14	2.81	26.09	232.8	-234.9	6.7	-6.7	122.3	24.3	17.9	6.3	12.4	89.4
1600	2.00	1.75	16.57	232.9	-234.3	4.2	-4.2	122.1	16.5	12.6	5.8	12.2	87.1
1700	0.42	0.27	3.87	213.4	-214.3	0.9	-0.9	121.7	7.4	4.9	4.4	8.4	44.8
1800	0.00	-0.03	0.03	26.1	-26.2	0.0	0.0	122.0	5.5	0.6	2.9	0.1	0.0
1900	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.5	5.5	-0.1	2.2	0.0	0.0
2000	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.7	5.5	-0.8	1.5	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.9	5.5	-1.5	0.9	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.0	5.4	-1.5	0.8	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.0	5.4	-1.2	0.9	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	119.0	5.4	-1.5	0.7	0.0	0.0

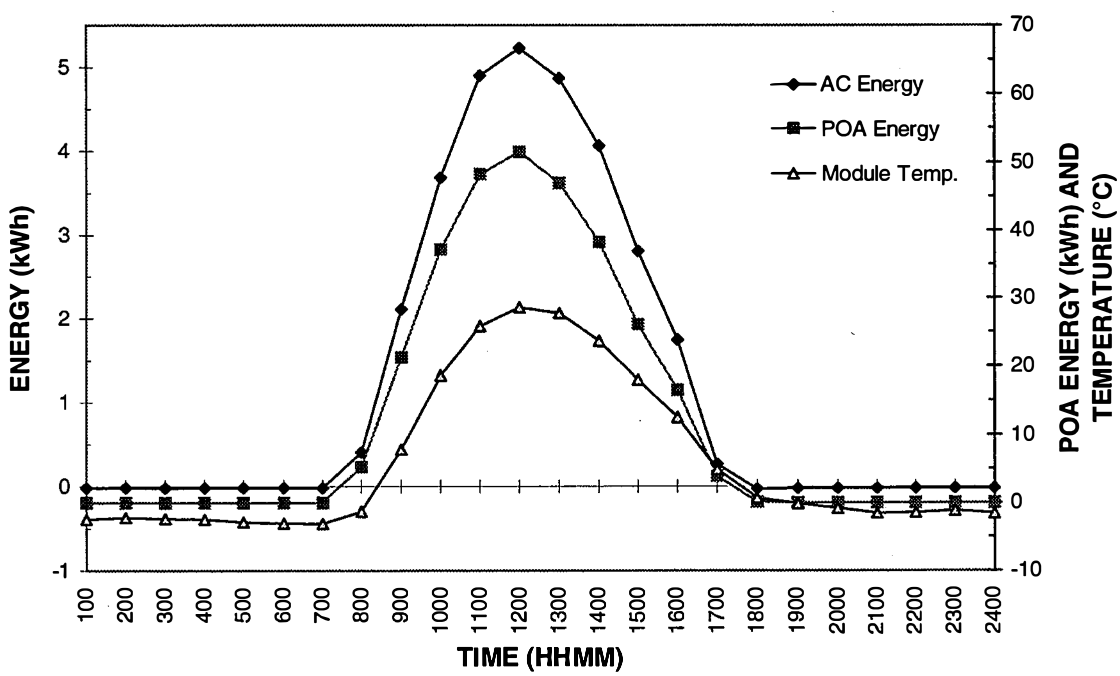

Figure D.9 (f). January 1995.

SERFWEST SYSTEM

AVERAGE DAILY PERFORMANCE BY HOUR FOR FEBRUARY, 1995

TIME	DC ENERGY kWh	ACENERGY kWh	INSOL kWh	ARRAY V POS Vdc	ARRAY V NEG Vdc	ARRAY I POS A	ARRAY I NEG A	INV V Vac	INV I A	ARRAY TEMP DEG C	AMBIENT TEMP DEG C	ARRAY EFF %	INVERTER EFF %
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.3	5.6	-0.3	1.5	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.3	5.6	-0.7	1.2	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.3	5.6	-1.0	0.9	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.1	5.6	-0.9	1.1	0.0	0.0
500	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.0	5.6	-0.9	1.1	0.0	0.0
600	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.0	5.6	-1.3	0.6	0.0	0.0
700	0.04	-0.01	0.39	44.9	-45.1	0.1	-0.1	121.6	5.8	-1.5	0.4	0.8	7.7
800	1.28	1.07	11.37	211.3	-212.4	2.7	-2.6	121.5	12.6	3.1	1.1	8.6	79.5
900	3.25	2.90	28.21	230.7	-232.1	6.9	-6.9	121.7	26.2	14.4	3.5	10.3	89.2
1000	4.55	4.06	39.94	229.0	-232.3	9.9	-9.9	121.9	35.3	22.5	5.2	10.5	89.1
1100	5.12	4.52	46.05	226.8	-230.2	11.2	-11.3	122.0	38.4	26.4	6.5	10.4	88.3
1200	5.46	4.79	49.85	225.3	-228.7	12.0	-12.1	122.1	40.1	30.2	7.8	10.2	87.9
1300	5.07	4.47	46.15	225.1	-228.2	11.2	-11.2	122.2	37.5	28.4	8.5	10.2	88.2
1400	4.71	4.20	44.01	225.7	-228.6	10.4	-10.4	122.0	35.3	26.2	8.7	10.1	89.1
1500	3.44	3.08	31.72	230.1	-232.4	7.5	-7.5	121.6	26.8	20.9	8.3	10.3	89.5
1600	2.21	1.96	20.29	229.4	-230.9	4.7	-4.7	121.4	18.5	15.6	7.8	10.1	88.4
1700	1.06	0.87	10.42	222.2	-223.0	2.2	-2.3	121.1	10.8	10.1	6.9	9.0	79.5
1800	0.07	-0.01	0.87	115.8	-116.2	0.2	-0.2	121.1	5.9	4.2	5.2	2.7	10.2
1900	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	121.7	5.5	1.7	3.6	0.0	0.0
2000	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	121.9	5.6	1.1	2.7	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.0	5.6	0.3	2.0	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.1	5.6	0.0	1.7	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.2	5.6	-0.4	1.3	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.3	5.6	-0.5	1.1	0.0	0.0

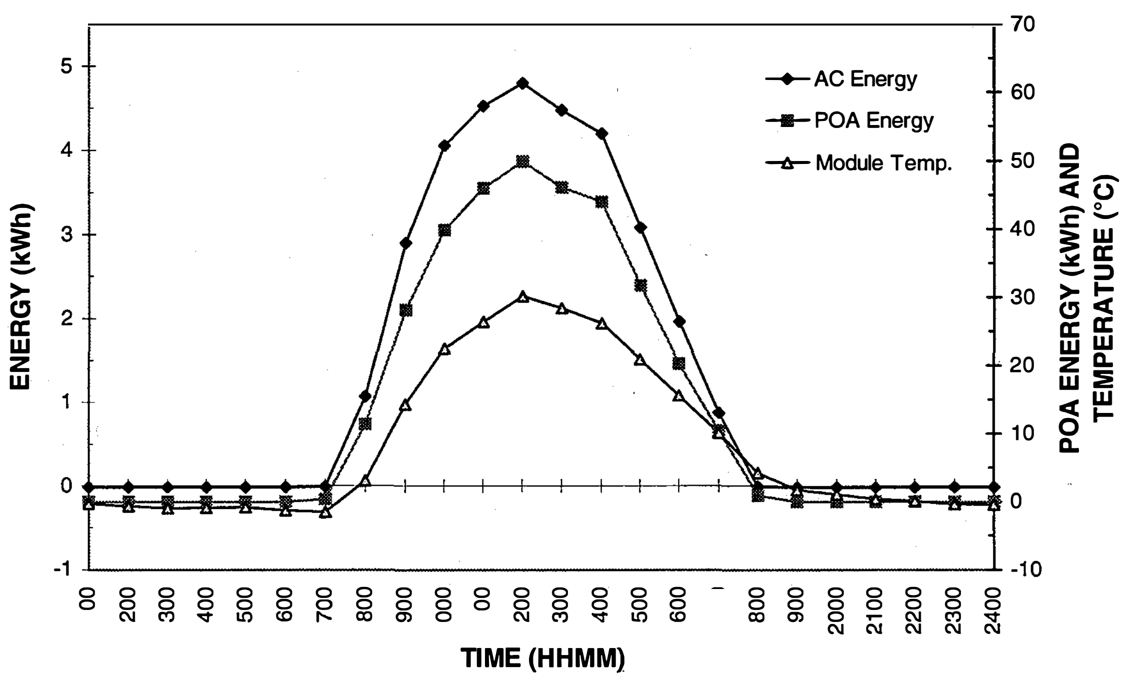

Figure D.9 (g). February 1995.

SERFWEST SYSTEM

AVERAGE DAILY PERFORMANCE BY HOUR FOR MARCH, 1995

TIME	DC ENERGY kWh	AC ENERGY kWh	INSOL kWh	ARRAY V POS Vdc	ARRAY V NEG Vdc	ARRAY I POS A	ARRAY I NEG A	INV V Vac	INV I A	ARRAY TEMP DEG C	AMBIENT TEMP DEG C	ARRAY EFF %	INVERTER EFF %
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.2	5.5	0.7	2.8	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.3	5.5	0.2	2.3	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.3	5.5	-0.3	1.9	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.2	5.5	-0.5	1.6	0.0	0.0
500	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.0	5.5	-0.6	1.5	0.0	0.0
600	0.00	-0.02	0.03	9.1	-9.0	0.0	0.0	118.0	5.6	-0.7	1.3	0.0	0.0
700	0.43	0.29	4.71	181.7	-182.3	0.9	-0.9	117.6	7.5	0.8	1.6	5.4	46.6
800	1.76	1.52	17.40	231.3	-232.4	3.7	-3.7	117.7	15.6	7.9	3.2	9.0	86.3
900	2.96	2.64	30.07	232.2	-234.2	6.4	-6.4	117.7	24.1	16.4	4.7	9.2	89.0
1000	3.97	3.52	40.03	229.4	-231.8	8.7	-8.7	119.0	30.5	23.5	6.3	9.6	88.8
1100	4.69	4.14	44.95	225.9	-228.6	10.3	-10.3	121.1	34.8	27.3	7.7	10.2	88.2
1200	5.14	4.53	49.97	229.2	-232.4	11.3	-11.3	118.3	37.5	29.6	8.8	10.2	88.0
1300	5.33	4.71	51.05	228.0	-231.0	11.8	-11.8	118.4	38.5	31.5	9.7	10.4	88.3
1400	4.40	3.93	41.84	229.3	-232.4	9.7	-9.7	118.1	32.5	28.5	10.2	10.7	89.3
1500	3.44	3.09	30.87	231.1	-233.6	7.5	-7.5	117.9	26.3	23.8	10.3	11.1	89.8
1600	2.26	2.00	20.37	234.1	-235.9	4.8	-4.8	117.6	18.2	18.3	10.1	10.9	88.6
1700	0.99	0.80	10.03	229.5	-230.4	2.1	-2.1	117.4	9.9	12.5	9.3	9.7	79.7
1800	0.17	0.04	2.10	204.8	-205.6	0.4	-0.4	117.4	6.1	7.4	8.1	6.9	23.3
1900	0.00	-0.03	0.04	29.2	-29.3	0.0	0.0	117.7	5.5	4.3	6.5	0.1	0.0
2000	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.0	5.4	3.1	5.6	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.0	5.5	2.5	5.0	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.0	5.5	2.1	4.5	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.1	5.5	1.9	4.1	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.2	5.5	1.7	3.7	0.0	0.0

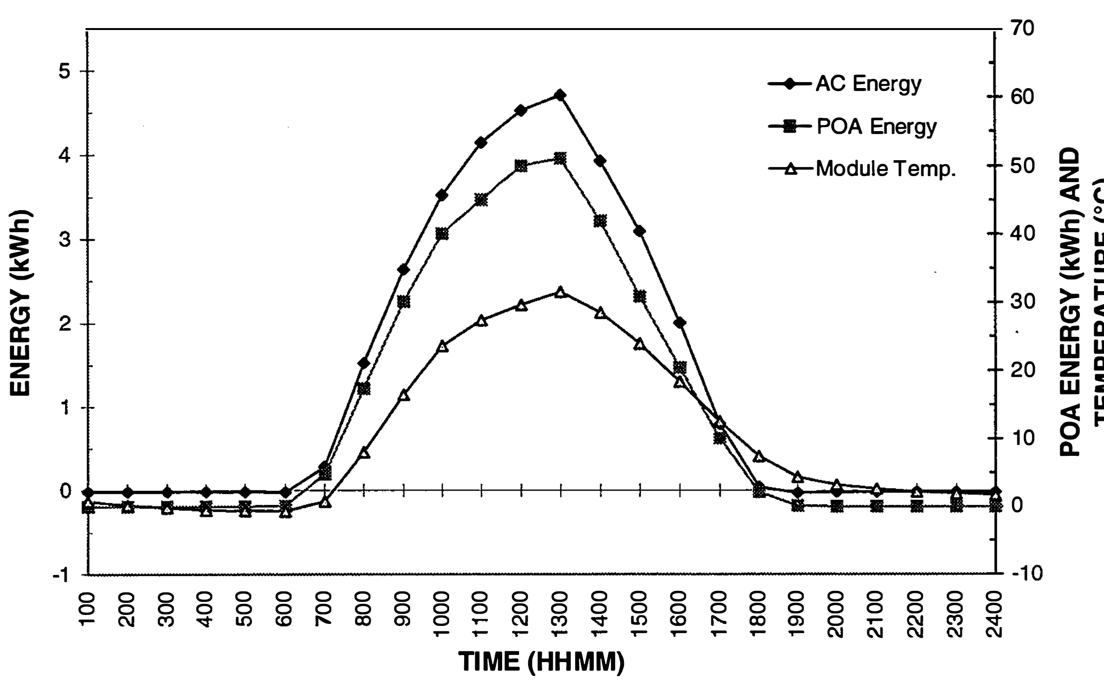

Figure D.9 (h). March 1995.

SERFWEST SYSTEM

AVERAGE DAILY PERFORMANCE BY HOUR FOR APRIL, 1995

TIME	DC ENERGY kWh	AC ENERGY kWh	INSOL kWh	ARRAY V POS Vdc	ARRAY V NEG Vdc	ARRAY I POS A	ARRAY I NEG A	INV V Vac	INV I A	ARRAY TEMP DEG C	AMBIENT TEMP DEG C	ARRAY EFF %	INVERTER EFF %
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.8	5.6	1.8	3.6	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.8	5.6	1.5	3.3	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.7	5.6	1.0	2.8	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.6	5.6	0.9	2.7	0.0	0.0
500	0.00	-0.02	0.00	0.1	-0.1	0.0	0.0	122.6	5.6	0.9	2.8	0.0	0.0
600	0.05	-0.02	0.84	106.9	-106.9	0.1	-0.1	122.0	5.9	1.2	2.7	2.1	4.0
700	0.68	0.49	7.84	229.6	-230.0	1.4	-1.4	121.7	8.9	4.0	3.4	7.8	67.1
800	1.75	1.50	18.11	236.0	-237.2	3.7	-3.6	121.8	15.6	9.9	4.6	9.3	85.4
900	2.98	2.65	28.37	228.9	-230.9	6.5	-6.4	121.9	24.0	18.0	6.3	9.9	88.7
1000	3.87	3.44	36.34	224.9	-227.2	8.5	-8.5	122.1	29.7	24.4	7.8	10.2	88.8
1100	4.26	3.74	41.55	228.0	-229.3	9.3	-9.3	122.2	31.6	27.6	8.8	10.4	87.9
1200	4.35	3.84	40.99	228.6	-230.7	9.6	-9.6	122.4	32.2	28.4	9.5	10.8	88.1
1300	4.11	3.63	38.04	227.5	-229.8	9.0	-9.1	122.4	30.6	27.5	10.2	11.0	88.3
1400	3.47	3.08	31.01	228.5	-230.9	7.6	-7.6	122.3	26.3	25.2	10.5	11.4	88.8
1500	2.76	2.46	24.12	227.2	-229.4	6.0	-6.0	122.2	21.8	21.9	10.7	11.7	89.0
1600	1.88	1.64	16.67	228.2	-229.8	4.0	-4.0	122.0	15.8	18.0	10.6	11.4	87.4
1700	0.85	0.67	8.61	224.1	-224.9	1.9	-1.8	121.9	9.3	12.7	9.7	10.1	77.2
1800	0.26	0.12	2.71	215.7	-216.2	0.6	-0.6	122.0	6.5	8.5	8.6	8.3	39.6
1900	0.03	-0.04	0.34	100.7	-100.6	0.1	-0.1	122.0	5.7	5.3	6.8	1.8	0.0
2000	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.3	5.5	3.8	5.8	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.5	5.5	3.3	5.2	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.5	5.6	2.9	4.7	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.6	5.6	2.7	4.4	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.7	5.6	2.1	3.8	0.0	0.0

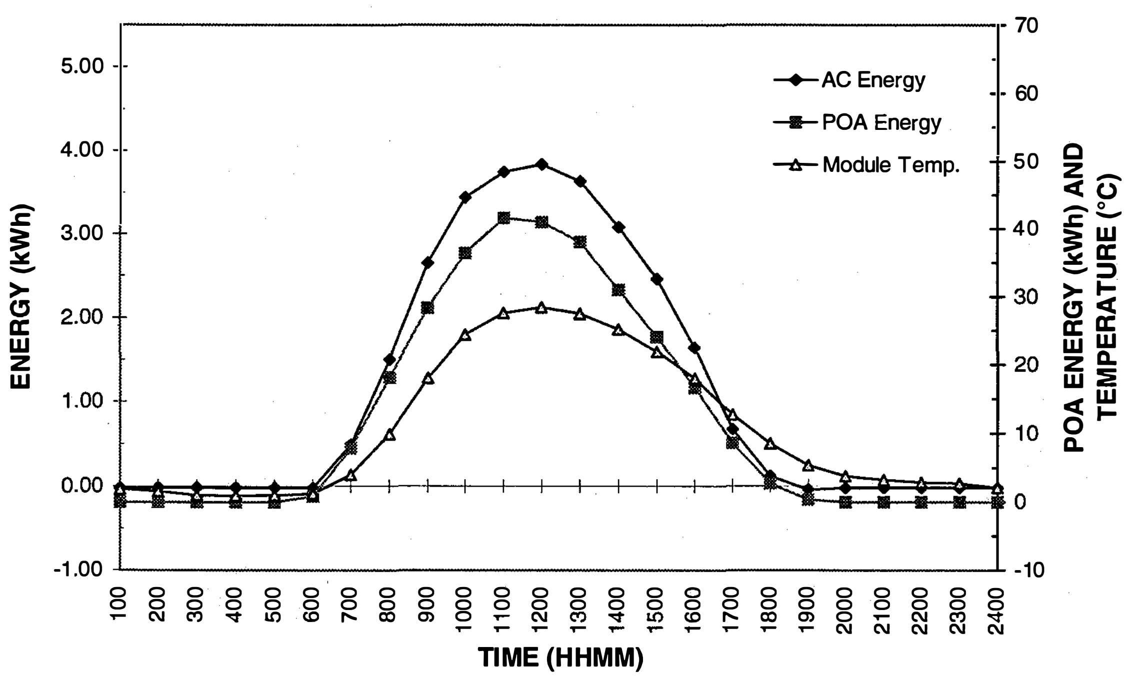

Figure D.9 (l). April 1995.

					SERFWEST SYSTEM								
				AVERAGE DAILY PERFORMANCE BY HOUR FOR MAY, 1995									
				ARRAY V	ARRAY V	ARRAY I	ARRAY I			ARRAY	AMBIENT	ARRAY	INVERTER
TIME	DC ENERGY	AC ENERGY	INSOL	POS	NEG	POS	NEG	INVV	INV I	TEMP	TEMP	EFF	EFF
	kWh	kWh	kWh	Vdc	Vdc	A	A	Vac	A	DEG C	DEG C	%	%
100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.7	5.7	4.9	6.8	0.0	0.0
200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.8	5.7	4.7	6.6	0.0	0.0
300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.8	5.7	4.4	6.3	0.0	0.0
400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.6	5.7	4.3	6.2	0.0	0.0
500	0.00	-0.03	0.05	31.1	-31.3	0.0	0.0	122.5	5.8	4.4	6.0	0.1	0.0
600	0.19	0.04	2.26	214.6	-215.5	0.4	-0.4	121.8	6.5	5.3	6.3	6.8	21.8
700	0.92	0.71	8.87	234.0	-235.1	1.9	-1.9	121.7	9.9	9.7	7.6	10.3	75.2
600	1.88	1.63	16.41	236.1	-237.6	4.0	-4.0	121.8	16.1	15.7	9.0	11.4	86.2
900	2.78	2.46	24.02	232.0	-234.0	6.0	-6.0	121.9	22.0	21.3	10.3	11.9	88.6
1000	3.46	3.06	30.54	231.4	-233.9	7.6	-7.6	122.0	26.3	25.9	11.7	12.0	88.4
1100	3.54	3.12	31.25	230.1	-232.6	7.7	-7.8	122.2	26.5	26.9	12.4	12.2	88.2
1200	3.73	3.30	33.13	229.8	-232.3	8.1	-8.2	122.4	27.8	28.7	13.1	12.1	88.4
1300	3.69	3.26	32.86	228.0	-230.5	8.1	-8.2	122.3	27.6	29.1	13.7	12.1	88.1
1400	2.79	2.46	24.30	226.9	-228.9	6.1	-6.2	122.2	21.8	25.1	13.7	12.3	88.3
1500	2.40	2.13	20.61	227.9	-229.8	5.2	-5.2	122.0	19.3	22.1	13.3	12.3	88.6
1600	1.58	1.36	13.75	227.6	-228.9	3.4	-3.4	121.9	13.8	19.3	13.2	11.9	85.8
1700	0.86	0.88	7.93	223.3	-224.2	1.9	-1.9	122.0	9.2	15.4	12.6	11.3	78.5
1800	0.40	0.24	3.65	219.4	-220.2	0.9	-0.9	122.2	7.0	12.6	11.9	10.1	58.2
1900	0.09	-0.03	1.00	186.3	-187.1	0.2	-0.2	122.1	6.1	10.1	10.8	4.5	5.1
2000	0.00	-0.03	0.01	11.7	-11.8	0.0	0.0	122.1	5.6	7.9	9.5	0.0	0.0
2100	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.4	5.6	7.3	9.0	0.0	0.0
2200	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.4	5.6	6.6	8.3	0.0	0.0
2300	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.5	5.7	5.9	7.8	0.0	0.0
2400	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.6	5.7	5.5	7.4	0.0	0.0

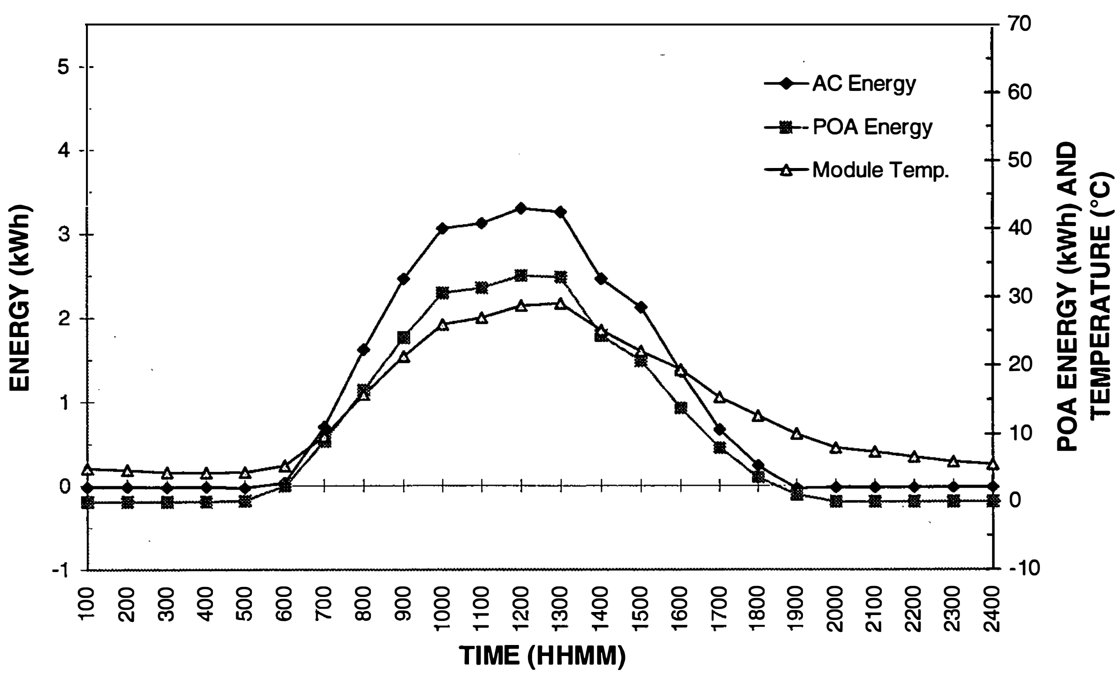

Figure D.9 (j). May 1995.

					SERFWEST SYSTEM								
					AVERAGE DAILY PERFORMANCE BY HOUR FOR JUNE, 1995								
				ARRAY V	ARRAY V	ARRAY I	ARRAY I			ARRAY	AMBIENT	ARRAY	INVERTER
TIME	DC ENERGY	AC ENERGY	INSOL	POS	NEG	POS	NEG	INVV	INV I	TEMP	TEMP	EFF	EFF
	kWh	kWh	kWh	Vdc	Vdc	A	A	Vac	A	DEG C	DEG C	%	%
100.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	110.2	5.1	11.5	13.8	0.0	0.0
200.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	110.3	5.1	11.4	13.7	0.0	0.0
300.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	110.3	5.1	11.1	13.4	0.0	0.0
400.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	110.2	5.1	10.9	13.1	0.0	0.0
500.0	0.01	-0.05	0.22	85.0	-85.4	0.0	0.0	110.0	5.3	10.7	12.8	0.6	0.0
600.0	0.22	0.07	3.16	225.7	-226.4	0.5	-0.5	109.5	5.9	12.1	13.3	6.9	29.6
700.0	0.77	0.55	11.33	247.4	-248.1	1.6	-1.6	113.3	8.5	17.4	14.7	7.7	69.5
800.0	1.85	1.59	21.11	240.4	-241.8	4.0	-4.0	113.5	15.4	25.6	16.7	9.2	86.0
900.0	3.26	2.93	32.00	229.0	-231.4	7.2	-7.3	113.9	24.3	33.6	18.7	10.8	89.9
1000.0	4.18	3.73	41.73	226.3	-229.1	9.4	-9.4	114.2	29.9	40.2	20.3	10.7	89.3
1100.0	4.20	3.72	42.44	226.6	-229.3	9.4	-9.5	114.2	29.8	41.7	21.3	10.6	88.5
1200.0	3.87	3.41	40.25	226.0	-228.4	8.7	-8.7	114.2	27.5	41.6	21.9	10.7	88.2
1300.0	3.78	3.33	37.38	223.6	-226.1	8.5	-8.5	117.2	27.2	39.8	22.3	11.1	88.3
1400.0	2.81	2.49	28.08	225.0	-227.1	6.3	-6.3	113.9	21.2	35.0	21.8	10.8	88.6
1500.0	2.18	1.93	21.53	227.1	-228.9	4.9	-4.9	112.9	17.2	31.7	21.8	10.3	88.5
1600.0	1.46	1.28	15.06	227.7	-229.0	3.3	-3.2	109.6	12.5	27.4	21.3	9.6	87.1
1700.0	0.77	0.62	8.98	227.2	-228.0	1.8	-1.7	109.6	8.3	23.9	20.7	8.4	79.0
1800.0	0.36	0.23	3.82	219.5	-220.2	0.8	-0.8	109.7	6.2	20.3	19.6	8.9	62.1
1900.0	0.16	0.04	1.83	210.0	-210.8	0.4	-0.4	109.6	5.6	18.0	18.3	6.6	25.2
2000.0	0.01	-0.05	0.18	80.8	-81.2	0.0	0.0	109.6	5.1	14.8	16.6	0.3	0.0
2100.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	110.0	5.0	13.5	15.5	0.0	0.0
2200.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	110.0	5.0	12.7	14.8	0.0	0.0
2300.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	110.1	5.1	12.3	14.3	0.0	0.0
2400.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	110.2	5.1	11.8	13.9	0.0	0.0

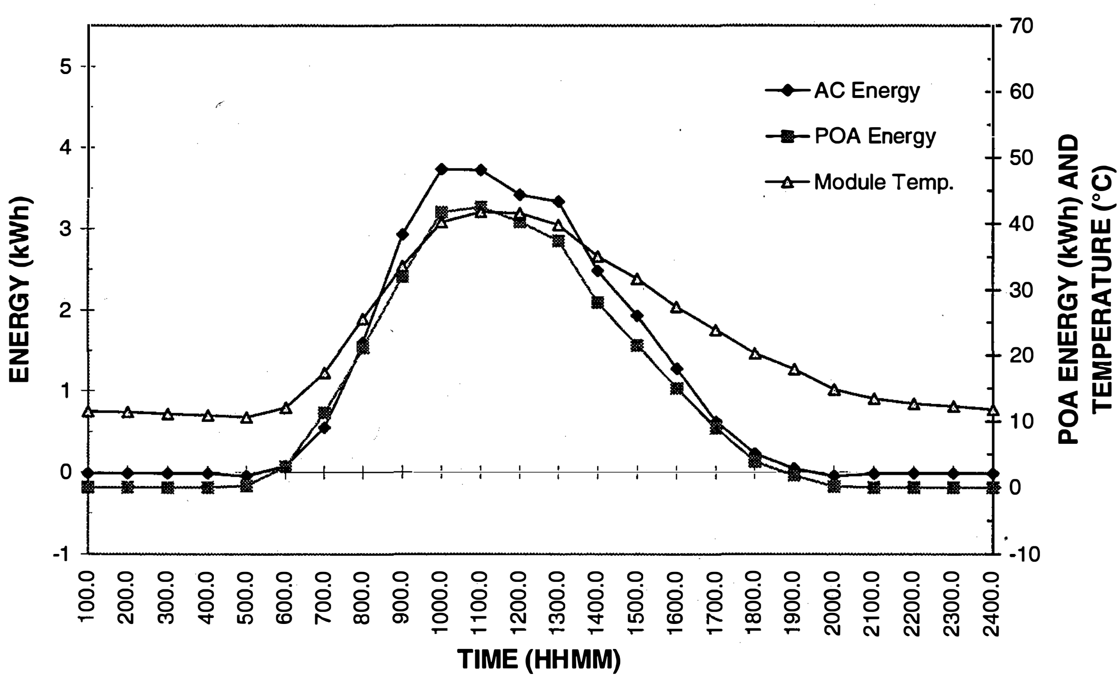

Figure D.9 (k). June 1995.

SERFWEST SYSTEM

AVERAGE DAILY PERFORMANCE BY HOUR FOR JULY, 1995

TIME	DC ENERGY kWh	AC ENERGY kWh	INSOL kWh	ARRAY V POS Vdc	ARRAY V NEG Vdc	ARRAY I POS A	ARRAY I NEG A	INV V Vac	INV I A	ARRAY TEMP DEG C	AMBIENT TEMP DEG C	ARRAY EFF %	INVERTER EFF %
100.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.2	5.7	16.4	18.7	0.0	0.0
200.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.2	5.7	16.0	18.3	0.0	0.0
300.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	122.1	5.7	15.6	18.0	0.0	0.0
400.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	120.4	5.6	15.1	17.5	0.0	0.0
500.0	0.00	-0.04	0.09	51.3	-51.6	0.0	0.0	117.9	5.6	14.8	17.2	0.1	0.0
600.0	0.19	0.04	2.62	218.6	-219.3	0.4	-0.4	117.1	6.3	16.1	17.7	6.5	23.2
700.0	0.67	0.43	11.80	257.7	-258.4	1.4	-1.3	117.1	7.9	21.7	19.4	6.1	62.1
800.0	1.55	1.29	23.54	248.7	-249.8	3.3	-3.3	117.2	13.5	31.6	21.7	7.0	82.5
900.0	2.94	2.60	33.81	232.6	-234.8	6.6	-6.5	117.6	22.3	39.9	23.7	8.9	88.4
1000.0	4.36	3.88	42.57	223.9	-227.0	9.8	-9.9	118.0	30.8	45.9	25.3	10.3	88.8
1100.0	4.55	4.01	44.69	222.3	-225.3	10.3	-10.4	118.1	31.7	47.7	26.3	10.3	88.2
1200.0	4.32	3.80	42.99	217.7	-219.0	9.8	-9.9	118.0	30.3	48.3	27.1	10.1	88.0
1300.0	4.05	3.57	39.92	221.7	-224.3	9.1	-9.2	117.9	28.5	47.1	27.8	10.6	88.0
1400.0	3.36	2.97	31.93	222.6	-225.0	7.6	-7.6	117.8	24.4	42.4	27.6	10.8	88.5
1500.0	2.89	2.58	26.90	221.9	-224.2	6.5	-6.6	117.7	21.7	38.9	27.4	11.0	89.4
1600.0	1.90	1.68	18.06	222.9	-224.3	4.3	-4.3	117.6	15.3	33.8	26.5	10.7	88.7
1700.0	0.96	0.79	10.44	220.4	-221.2	2.2	-2.1	117.5	9.4	29.1	25.7	9.2	81.6
1600.0	0.41	0.27	4.20	214.4	-215.1	1.0	-1.0	117.6	6.6	25.1	24.7	9.7	64.1
1900.0	0.16	0.03	1.84	210.2	-210.9	0.4	-0.4	117.5	5.9	22.5	23.3	7.7	21.9
2000.0	0.01	-0.05	0.16	74.2	-74.6	0.0	0.0	117.4	5.4	19.6	21.7	0.4	0.0
2100.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	117.8	5.3	18.2	20.6	0.0	0.0
2200.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	117.9	5.4	17.9	20.1	0.0	0.0
2300.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.0	5.4	17.2	19.4	0.0	0.0
2400.0	0.00	-0.02	0.00	0.0	0.0	0.0	0.0	118.2	5.5	16.6	18.9	0.0	0.0

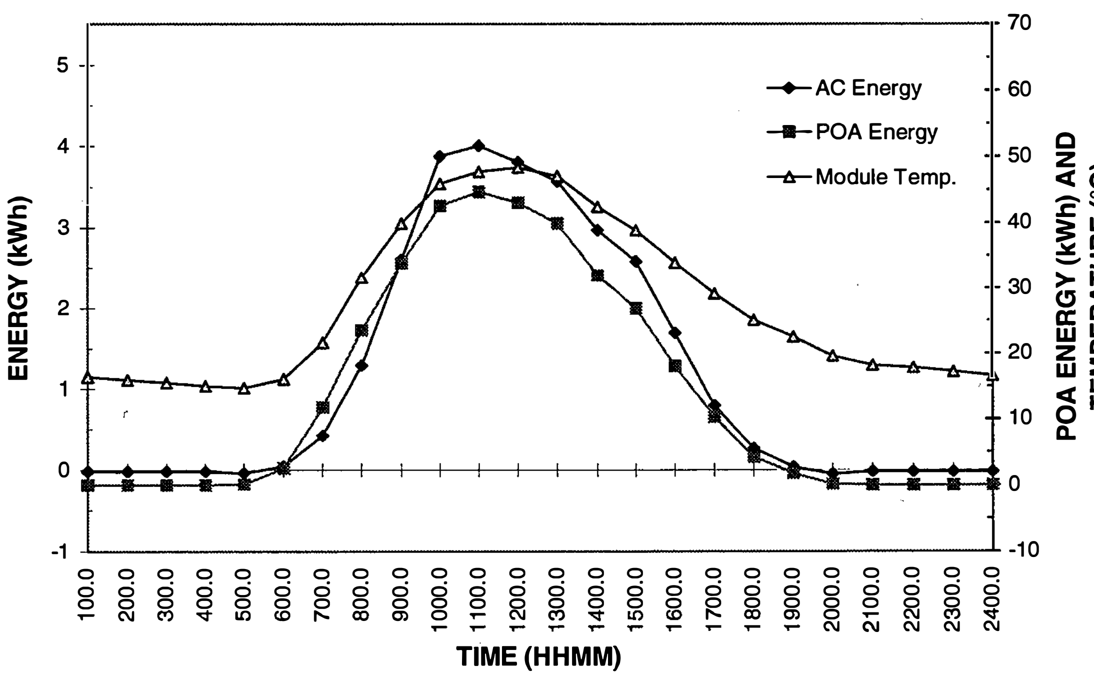

Figure D.9 (l). July 1995.

Noon Temperatures - SERFWEST System			
	Back-of-		
	Module	Ambient	Temp.
Month	Temp.	Temp.	Delta
Aug-94	47.7	27.6	20.1
Sep-94	46.5	23.9	22.6
Oct-94	36.1	15.2	20.9
Nov-94	20.0	6.8	13.2
Dec-94	28.3	7.8	20.5
Jan-95	28.5	6.6	21.9
Feb-95	31.1	8.2	22.9
Mar-95	30.9	9.2	21.7
Apr-95	27.2	9.7	17.5
May-95	28.9	13.4	15.5
Jun-95	40.8	22.0	18.8
Jul-95	48.9	27.5	21.4

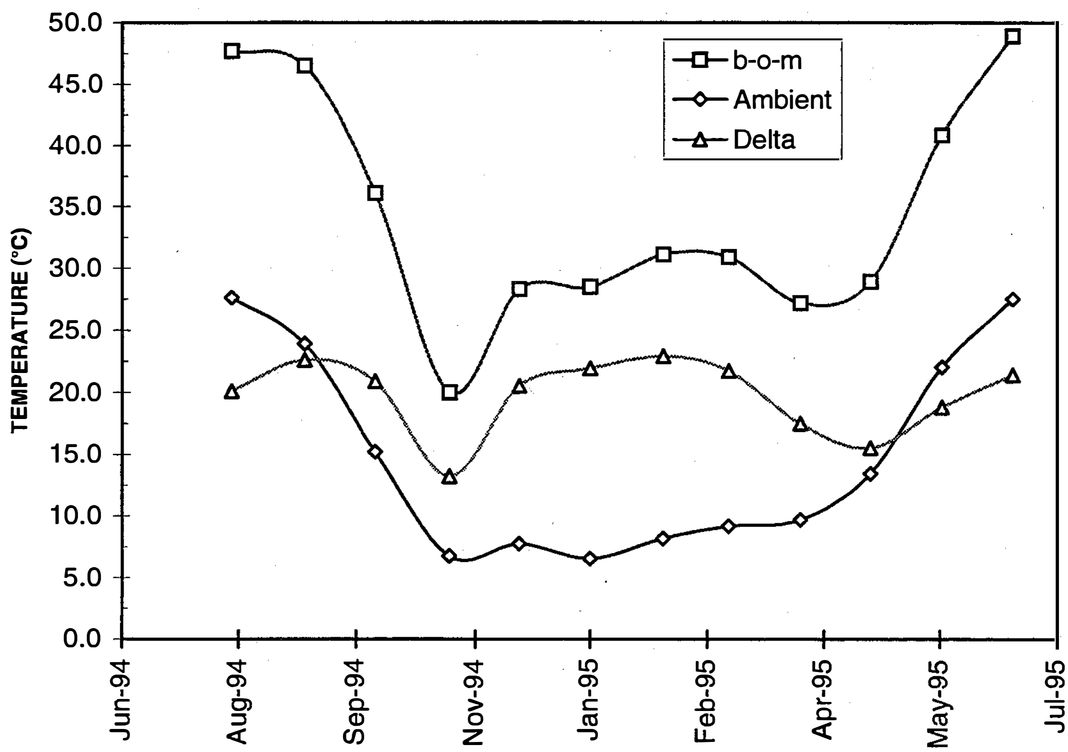

Figure D.9 (m). Comparison of monthly noon temperatures.

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13. ABSTRACT *(Maximum 200 words)*
This report presents an analysis of performance data on the two identical, $6kW_{ac}$, grid-connected photovoltaic systems located on the roof of the Solar Energy Research Facility building at the National Renewable Energy Laboratory in Golden, Colorado. The data cover the monitoring period August 1, 1994, to July 31, 1995, and the performance parameters analyzed include direct current and alternating current power, aperture-area efficiency, energy, capacity factor, and performance index. These parameters are compared to plane-of-array irradiance, ambient temperature, and back-of-module temperature as a function of time, either daily or monthly. We also obtained power ratings of the systems for date corresponding to different test conditions. This study has shown, in addition to expected seasonal trends, that system monitoring is a valuable tool in assessing performance and detecting faulty equipment. Furthermore, methods applied for this analysis may be used to evaluate and compare systems using cells of different technologies. The systems were both found to be operating at approximately 7% below their estimated rating, which was based on Photovoltaics for Utility-Scale Applications test conditions. This may be attributed to the design inverter efficiency being estimated at 95% compared to measured values of approximately 88%, as well as the fact that the aperture-area efficiency that was overestimated at 12.8% compared to a measured value of 11.0%. The continuous monitoring also revealed faulty peak-power point tracking equipment.

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