Contract Report

Evaluation of the PV Systems at Martin Power Plant

FSEC-CR-1011-98

Submitted to:
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July 14, 1998

(Revised July 23, 1998)

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FSEC-CR-1011-98
Contract No. AV-5590
Acct. No. 26-57-892

Tests Performed June 3, 1998
Report Submitted July 14, 1998
Revised July 23, 1998

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

On June 3, 1998, researchers from the Florida Solar Energy Center (FSEC) conducted a field test of six, independent photovoltaic (PV) systems at the Florida Power and Light (FPL) Martin Power Plant.

The weather conditions during test were hazy with a few clouds. This test was performed at the request of FPL to determine the operational status of the PV systems and to provide recommendations for upgrading or repairing these systems. Of the six systems, three were fully operational and were providing power to the grid. Figures 1 and 2 below show the Martin Power Plant PV systems.

Figures 1 and 2. Martin Power Plant PV Systems

Several performance measurements were obtained for each array, using an IV curve tracer and then scaled to 1000W/m^2 and 45°C. The average peak power for each of the systems is given in the table below.

Table 1. Performance Measurements

System	Module Manufacture	Normalized Array Rating 1000 W/m^2 and 45°C	Status
1	Sovonics, P201	1755Watts	Off-line, Ground Fault
2	Mobil, RA180-36	3396 Watts	Operational
3	Kyocera,LA661K94	3004 Watts	Operational
4	Kyocera, LA661K94	3047 Watts	Operational
5	ARCO, M52-S	5947 Watts	Off-line, Partially Installed
6	Hoxan, H4810	4399 Watts	Off-line, Inverter Problems

In addition, each system was visually inspected and evaluated. The evaluations and conditions noted for each system are described separately in the *System Performance* section.

SITE DESCRIPTION

The Martin Power Plant PV site is located east of Indiantown near Lake Okeechobee at the main FPL generation plant for Central Florida. The PV facility consists of six grid-connected systems installed in the late 1980s and early 1990s. Figure 3 below shows the arrays configured in two rows and identified by module manufacturer and system number.

Each of the systems is described separately in the following subsections.

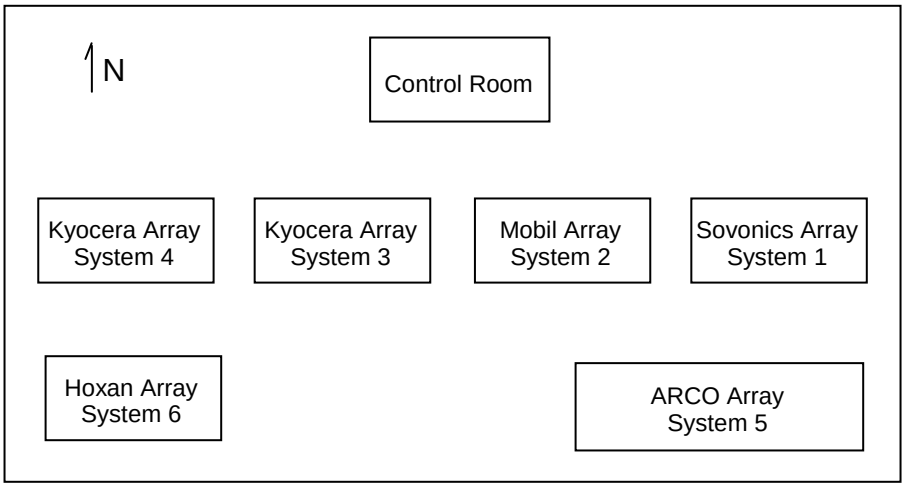

Figure 3. Array Field Layout

The control room, shown north of the arrays, houses the power conditioning equipment, dc summing junction boxes, disconnect switches, monitoring equipment and data acquisition system (DAS). The output of the PV power plant is connected to a three-phase grid situated east of the control room (Figure 4).

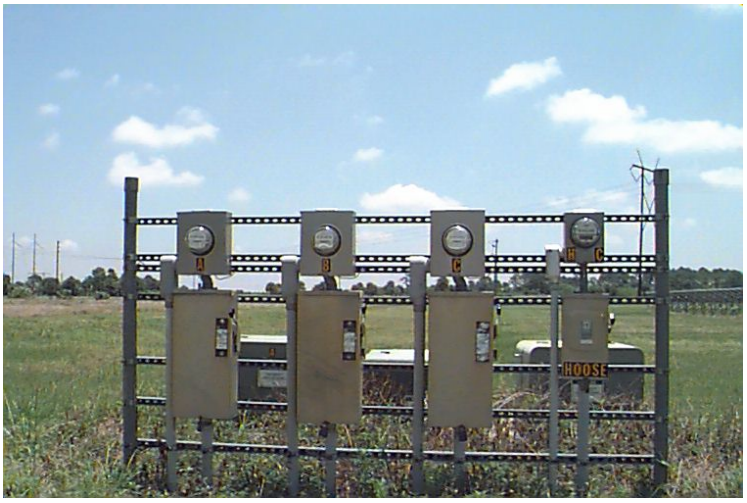

Figure 4. Grid Interconnect and Metering Equipment

System 1 – Sovonics

The array consists of 180 Sovonics P201 modules, mounted on a galvanized angle iron rack at a fixed tilt of 26 degrees (Figure 5). The array is configured in twelve strings of fifteen modules in series, which are divided evenly between the positive and negative source circuits. The original array rating at standard test conditions (STC) of 1000 W/m^2 and 25°C was 4,140 Watts. The nameplate rating of the individual Sovonics modules at STC is 21 Watts peak, Voc=22 volts, Isc=1.6 amps, Vpp= 16.3 volts, and Ipp= 1.3 amps. The array physical configuration and module serial numbers are given in Appendix B.

Figure 5. Sovonics Array

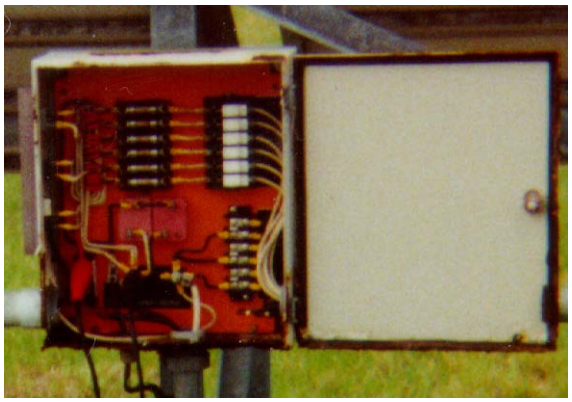

Figure 6. System 1 Source Circuit Junction Box

The source circuit junction box, mounted under the array, contains the blocking diodes, fuses, surge protection equipment and disconnect switches (Figure 6). The output of the array is connected to the combiner box in the control room (Figure 7). This box contains the fuses and monitoring equipment for Systems 1 and 2.

The system utilizes a 4-kW Omnion, Series 2200, Model # 04-6-1 Serial Type #1025 inverter connected to one phase of the three-phase grid. It has a dc input range of +/- 225 Vdc and an ac output of 120 Vac, 35 Aac, 60 Hz. An ac junction box, located next to the inverter, houses the fuses, surge protectors and monitoring equipment (Figure 8).

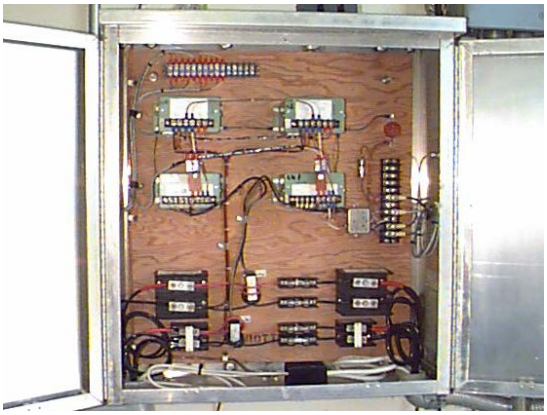

Figure 7. System 1 Combiner Box

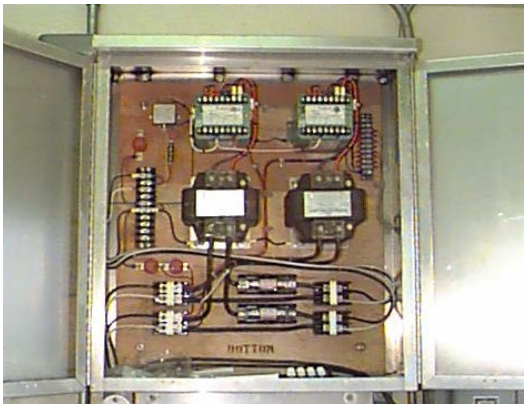

Figure 8. System 1 AC Junction Box

System 2 – Mobil

This array consists of 20 Mobil RA180-36 modules, mounted on a galvanized pipe and angle rack at a fixed tilt of 26 degrees (Figure 9). The array is configured in four strings of five modules in series. The original power rating for this module could not be determined but typically these modules have been rated at 180 Watts peak. Assuming the 180-Watt rating, the initial rating for the array was about 3600 Watts. The array physical configuration and module serial numbers are given in Appendix B.

Figure 9. Mobil Array

The source circuit junction box, mounted under the array, contains the blocking diodes, fuses, surge protection equipment and disconnect switches (Figure 10). The output of the array is connected to the combiner box in the control room (Figure 11). This box contains the fuses and monitoring equipment for Systems 1 and 2.

Figure 10. System 2 Source Circuit Junction Box

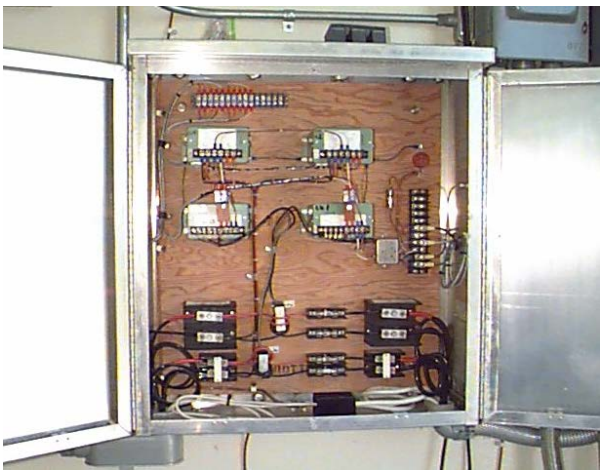

Figure 11. System 2 Combiner Box

The system utilizes a 4-kW Omnion, Series 2200, Model # 04-6-1 Serial Type #1025 inverter, which is connected to one phase of the three-phase grid. It has a dc input range of +/- 225 Vdc and an ac output of 120 Vac – 35 Aac – 60 Hz. An ac junction box, located next to the inverter, houses the fuses, surge protectors and monitoring equipment (Figure 12).

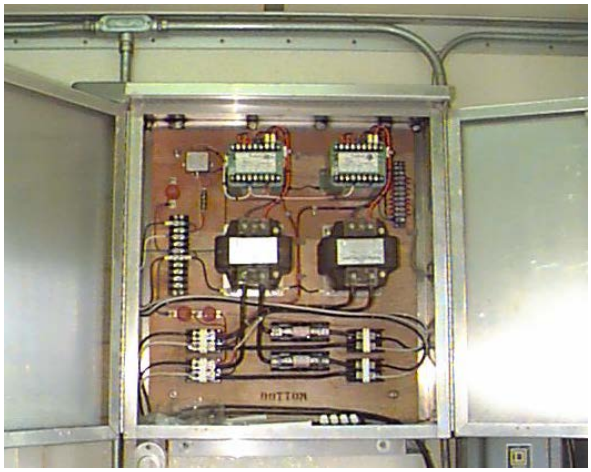

Figure 12. System 2 AC Junction Box

System 3 – Kyocera

The array consists of 42 Kyocera LA661K94 multi-crystalline modules manufactured in 1990 (Figure 13). The 66-cell modules are mounted on a galvanized "I" beam rack at a fixed tilt of 23 degrees. The array is configured in six strings of seven modules in series, with the strings connected three in parallel to form the two bipolar sub-arrays, +/- 232 Vdc.

Figure 13. Kyocera Array

The original array rating at STC was approximately 3,900 watts. The name-plate rating of the individual Kyocera modules at STC is 93.6 Watts peak, Voc=31.0 volts, and Isc=3.02 amps. The array physical configuration and module serial numbers are given in Appendix B.

The source circuit junction box, mounted under the array, contains the blocking diodes, fuses, surge protection and disconnect switches (Figure 14). The output of the array is connected to the combiner box in the control room (Figure 15). The combiner box contains the fuses and monitoring equipment for Systems 3 and 4.

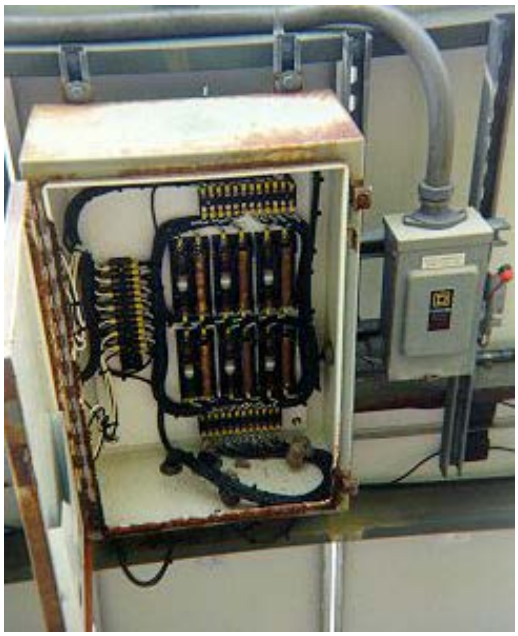

Figure 14. System 3 Source Circuit Junction Box

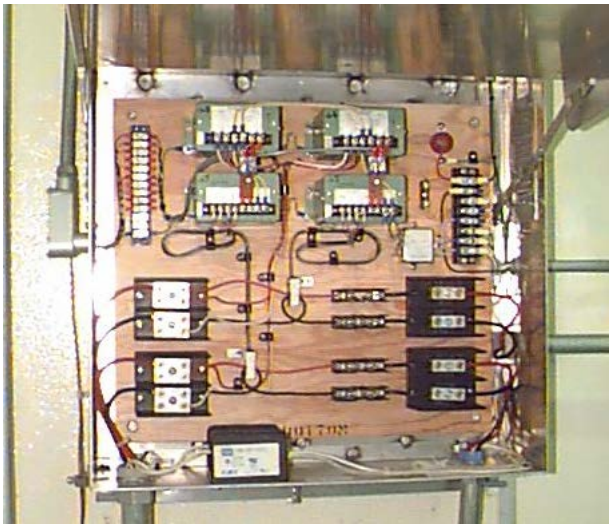

Figure 15. System 3 Combiner Box

This system utilizes a 4-kW Omnion, Series 2200, Model # 04-6-1 Serial Type #1025 inverter, which is connected to one phase of the three-phase grid. It has a dc input range of +/- 225 Vdc and an ac output of 120 Vac – 35 Aac – 60 Hz. An ac junction box, located next to the inverter, houses the fuses, surge protection and monitoring equipment (Figure 16).

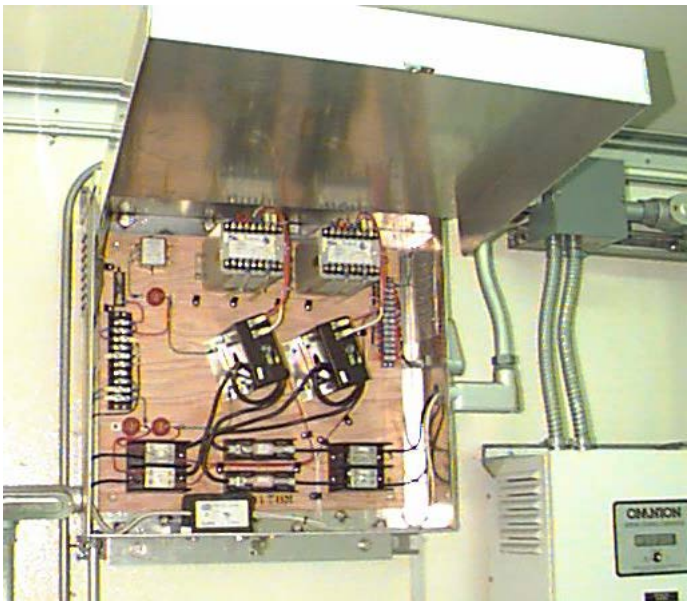

Figure 16. System 3 AC Junction Box

System 4 - Kyocera

The array consists of 42 Kyocera LA661K94 multi-crystalline modules manufactured in 1990 (Figure 17). The 66-cell modules are mounted on a galvanized "I" beam rack at a fixed tilt of 23 degrees. The array is configured in six strings of seven modules in series, with the strings connected three in parallel to form the two bipolar sub-arrays, +/-232 Vdc. The original array rating at STC is approximately 3,900 watts. The nameplate rating of the individual Kyocera modules at STC is 93.6 Watts peak, Voc=31.0 volts, and Isc=3.02 amps. The module physical configuration and serial numbers are given in Appendix B.

Figure 17. Kyocera Array

The source circuit junction box, mounted under the array, contains the blocking diodes, fuses, surge protection equipment and disconnect switches (Figure 18). The output of the array is connected to the combiner box in the control room (Figure 19). This box contains the fuses and monitoring equipment for Systems 3 and 4.

Figure 18. System 4 Source Circuit Junction Box

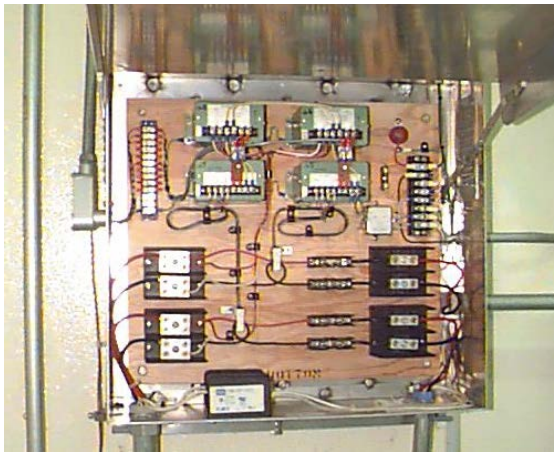

Figure 19. System 4 Combiner Box

This system operates with a 4-kW Omnion, Series 2200, Model # 04-6-1 Serial Type #1025 inverter, which is connected to one phase of the three-phase grid. It has a dc input range of +/- 225 Vdc and an ac output of 120 Vac – 35 Aac – 60 Hz. An ac junction box, located next to the inverter, houses the fuses, surge protectors and monitoring equipment (Figure 20).

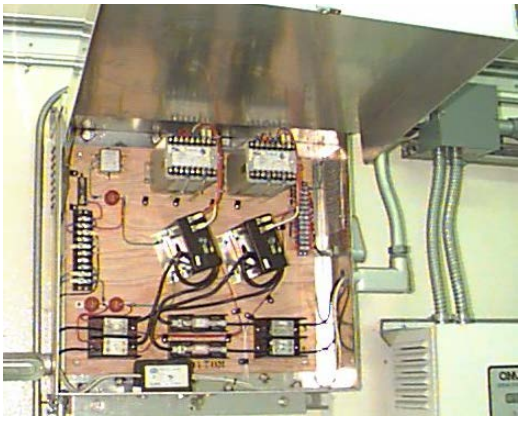

Figure 20. System 4 AC Junction Box

System 5 - ARCO

The array consists of 256 ARCO M52-S, Part # 004013985 single crystal modules manufactured in 1983 (Figure 21). The 36-cell modules are installed on a single-axis tracker, which is currently positioned horizontally (Figure 22). The axis of rotation is north to south, which allows for yearly array tilt changes but does not allow for daily tracking. The array physical configuration and module serial numbers are given in Appendix B.

Figure 21. ARCO Array

Figure 22. Tracker

This system is not connected to an inverter. The system was moved from another location and was never completely reinstalled. A DECC, model # 61289-54, three-phase inverter was placed in the control room, but the wiring was not finished.

System 6 – Hoxan

The array consists of 112 Hoxan H-4810 modules (Figures 23 and 24). The 36-cell modules are mounted on a Unistrut rack at a fixed tilt of 25 degrees. The modules are configured in eight strings of fourteen modules in series, with the strings connected four in parallel to produce two bipolar sub-arrays, +/- 135 vdc. The array physical configuration and module serial numbers are given in Appendix B.

Figures 23 and 24. Hoxan Array

The source circuit junction box (Figure 25), manufactured by Photron Inc., is mounted under the array and contains the blocking diodes, fuses, surge protection equipment and disconnect switches. The output of the array is connected to the combiner box in the control room (Figure 26). This box contains a circuit breaker.

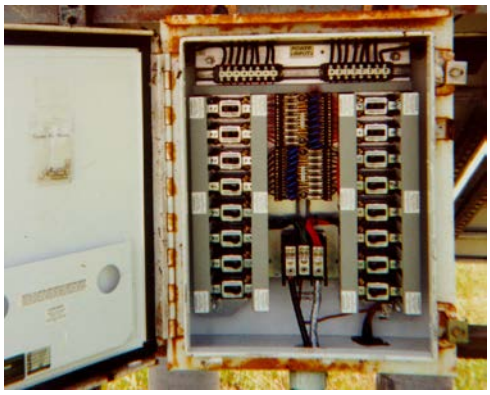

Figure 25. System 6 Source Circuit Junction Box

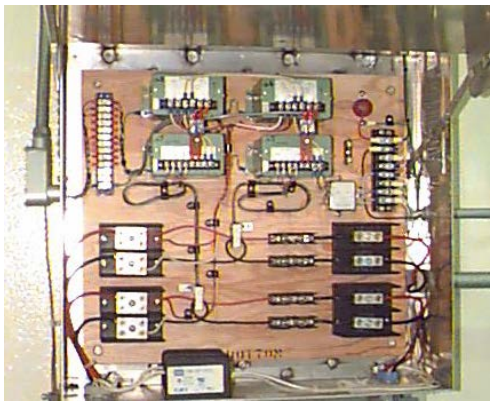

Figure 26. System 6 Combiner Box

The system uses a 5 kVA Abacus Inverter, Model 753-4-200, Serial #11233-01. It has a dc input range of 160-240 Vdc and an ac output of 240 Vac – 60 Hz – single phase. The inverter is connected to one phase of the three-phase grid. No ac junction box is used.

SYSTEM PERFORMANCE

In addition to the several performance measurements that were taken, each system was visually inspected and evaluated. The conditions noted for each system are described in the following subsections. (Also see Table 1 in the *Introduction* which shows the average peak power for each system.)

System 1 – Sovonics

The Sovonics system was not operating at the time of the test; the following conditions were identified.

1) The array seems to be undamaged, but the wiring from the source circuit junction box to the combiner box in the control room appears to have a ground fault.
2) Two fuses in the Omnion inverter are blown, the negative source circuit fuse and the ac output fuse. The condition of these fuses and the array wiring ground fault are most likely the cause of the inverter malfunction.
3) The source circuit junction boxes on the array are severely corroded on the outside, but the inside plates and the components mounted on the inside plate are still usable.
4) The array frames and mounting structure are currently ungrounded.
5) Several of the modules show signs of delamination (Table 2). (The groups are numbered east to west and the modules are number north to south.) The following table lists these modules, and a photograph of typical module delamination is shown in Figure 27.

Table 2. Modules Showing Signs of Delamination

Group 1 - Module 2	Group 11 - Module 3
Group 4 - Module 1	Group 11 - Module 4
Group 4 - Module 4	Group 15 - Module 1
Group 8 - Module 2	Group 20 - Module 4
Group 8 - Module 4	Group 21 - Module 3
Group 9 - Module 2	Group 24 - Module 3
Group 10 - Module 4	

Figure 27. Typical Sovonics Module Delamination

6) Five of the modules had moisture damage, Group 8 - Module 2, Group 19 - Module 3, Group 26 - Module 3, Group 26 - Module 4, and Group 26 - Module 6.
7) One module, Group 10 - Module 4, showed signs of corrosion.

Several IV curves of the array were taken during the test (Appendix A). The IV data were normalized to 1000 W/m^2 and 45°C. A temperature of 45°C was used to more closely represent the expected field performance.

Table 3. System 1 (Sovonics) System Performance

Curve Name	Measured Peak Power (W)	Measured Irradiance (W/m^2)	Measured Cell Temp. (°C)	Normalized Peak Power (W)
s1-iv02	1463.58	845.6	47	**1747.1**
s1-iv04	987.55	562.5	46	**1763.9**
s1-iv01	1454.67	836.8	47	**1754.7**
Sovonics Average Normalized System Peak Power				**1755 W**

Several IV curves of a single string were also taken during the test (Appendix A). The average normalized rating for a typical string was about 180 W at 1000 W/m^2 and 45°C.

System 2—Mobil

The Mobil system was functioning at the time of the test. The inverter output was about 2.3 kW under an irradiance of approximately 940 W/m^2. The following conditions were identified during the test.

1) The four array strings are configured in a single bipolar center-grounded array. The dc voltage measured with respect to ground is an indication of the array operating imbalance. The positive array was operating at +203Vdc and the negative array was operating at –239Vdc at the time of the testing. This represents an imbalance of 15% and is probably due to array/modules degradation.
2) The inverter efficiency was determined to be about 89% with a dc input of 2,500VAdc and an ac output of 2230VAac. This indicates that the inverter is operating at or above the original specification.
3) The source circuit junction boxes on the array are severely corroded, but the inside plates and the components mounted on the inside plate are still usable and operating.
4) Two modules were identified with problems. Module 4 had corrosion of the front contacts (Figure 28) and Module 6, a slight delamination (Figure 29).

Figure 28. Mobil Array Module 4 Corrosion

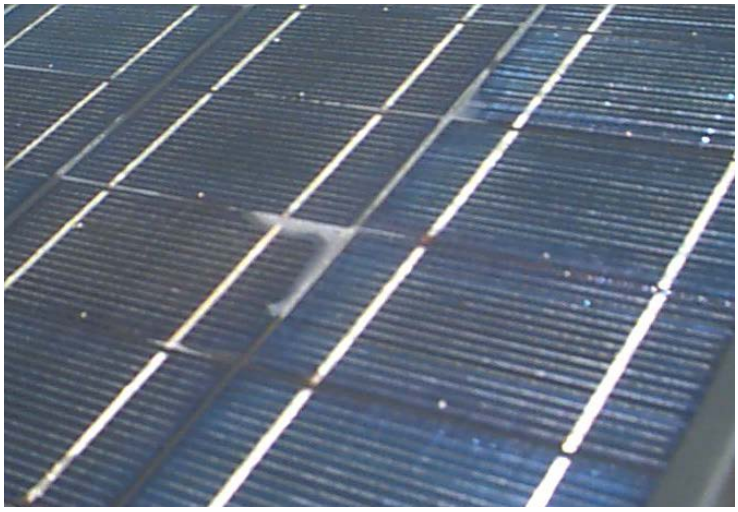

Figure 29. Mobil Array Module Delamination

5) Several IV curves of the array were taken during the test (Appendix A). The IV data were normalized to 1000 W/m^2 and 45°C. A temperature of 45°C was used to closely represent the expected field performance.

Table 4. System 2 (Mobil) System Performance

Curve Name	Measured Peak Power (W)	Measured Irradiance (W/m^2)	Measured Cell Temp. (°C)	Normalized Peak Power (W)
s2-iv07	3050.89	938.0	55	**3405.4**
s2-iv09	3026.46	935.9	55	**3385.7**
s2-iv10	3039.4	936.8	55	**3396.9**
Mobil Average Normalized System Peak Power				**3396 W**

System 3 – Kyocera

The Kyocera system was also functioning at the time of the test. A visual walk-through was conducted and the modules and the array structure were found to be in good condition. The inverter was producing about 1.5 kW under an irradiance of about 940 W/m^2. The following conditions were identified during the test.

1) The array dc operating voltages were +198Vdc and –226Vdc, an imbalance of 13%.
2) The inverter efficiency was about 93% with a dc input of 1587 VAdc and an ac output of 1484 VAac.
3) The module frames are not grounded using a grounding conductor, but instead rely on the physical contact between the module frames and the "I" beams. The "I" beam frame is connected to earth in one location using a ground rod.
4) The summing junction boxes on the array are severely corroded on the outside, but the inside plates and the components mounted on the inside plate are still usable and operating.
5) The modules are all in good condition. Several IV curves of the array were taken during the test (Appendix A). The IV data were normalized to 1000 W/m^2 and 45°C. A temperature of 45°C was used to closely represent the expected field performance.

Table 5. System 3 (Kyocera) System Performance

Curve Name	Measured Peak Power (W)	Measured Irradiance (W/m^2)	Measured Cell Temp. (°C)	Normalized Peak Power (W)
s3-iv07	2680.15	935.0	55	**3001.2**
s3-iv08	2701.41	941.2	55	**3005.1**
s3-iv09	2694.92	941.4	55	**2997.2**
s3-iv10	2707.44	941.2	55	**3011.8**
Kyocera (System 3) Average Normalized System Peak Power				**3004 W**

System 4 – Kyocera

The second Kyocera system was also functioning at the time of the test, and the array was in good condition. The inverter was producing about 1.1 kW under an irradiance of about 927 W/m^2. The following conditions were identified during the test.

1) The array dc voltages during normal operation were +205 Vdc versus –222 Vdc, an imbalance of 8%.
2) The inverter efficiency was about 86% with a dc input of 1065 VAdc and an ac output of 918 VAac.
3) The module frames are not grounded using a grounding conductor, but instead rely on the physical contact between the module frames and the "I" beams. The "I" beam frame was connected to earth in one location with a ground rod, but the bare conductor has been cut.
4) The source circuit junction boxes on the array are severely corroded on the outside, but the inside plates and the components mounted on the inside plate are still usable and operating.
5) The modules are all in good condition. Several IV curves of the array were taken during the test (Appendix A). The IV data were normalized to 1000 W/m^2 and 45°C. A temperature of 45°C was used to closely represent the expected field performance.

Table 6. System 4 (Kyocera) System Performance

Curve Name	Measured Peak Power (W)	Measured Irradiance (W/m^2)	Measured Cell Temp. (°C)	Normalized Peak Power (W)
s4-iv07	2724.56	933.2	55	**3056.8**
s4-iv08	2710.49	931.5	55	**3046.6**
s4-iv09	2704.17	932.0	55	**3037.8**
s4-iv10	2713.82	932.9	55	**3045.7**
Kyocera (System 4) Average Normalized System Peak Power				**3047 W**

System 5 – ARCO

This system has not been completely installed. The following conditions were identified during the test.

1) The array mounting structure and ground are in good condition.
2) The source circuit junction box and tracking equipment are also in good condition.
3) The system is currently not configured for active tracking. The axis of rotation is north-south, but presently the array is in a fixed horizontal position.
4) All of the modules exhibit EVA browning (Figure 30). This browning covers about 90% of each cell, with a picture frame area around the edge of each cell with less discoloration.
5) Two modules have cracked cells, Group 2 - Module 6 and Group 8 - Module 3.
6) One module has severe browning and corrosion and needs to be replaced, Group 10 - Module 7.

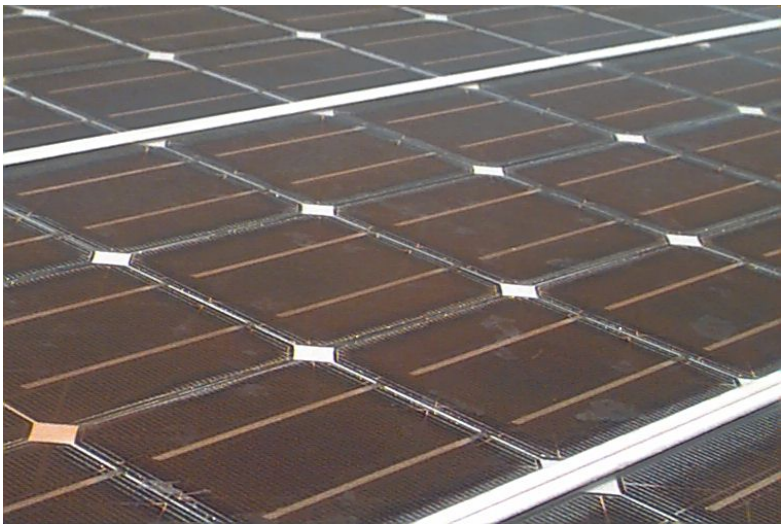

Figure 30. ARCO Array Typical EVA Discoloration

7) Several IV curves of the array were taken during the test (Appendix A). The IV data were normalized to 1000 W/m^2 and 45°C. A temperature of 45°C was used to closely represent the expected field performance.

Table 7. System 5 (ARCO) System Performance

Curve Name	Measured Peak Power (W)	Measured Irradiance (W/m^2)	Measured Cell Temp. (°C)	Normalized Peak Power (W)
s6-iv01	5590.78	989.1	56	**5944.6**
s6-iv03	5330.46	936.7	55	**5958.1**
s6-iv04	5489.59	966.0	55	**5949.9**
s6-iv06	5543.23	982.1	56	**5936.1**
ARCO Average Normalized System Peak Power				**5947 W**

System 6 – Hoxan

This system was not operating during the test, but the following conditions were identified.

1) The Abacus inverter was "ON," and the array voltage was present on the inputs but no output was observed. The inside of the inverter appeared undamaged.
2) The Unistrut module rack is severely rusted and in some places has lost structural integrity.
3) The source circuit junction box showed moderate signs of corrosion on the outside, but the inside plates and the components mounted on the inside plate are still usable and operating.
4) The array was basically in good condition with the exception of five modules. Group 6 -Module 2 showed signs of water damage in the lower right corner. Four modules had areas with corrosion: Group 1-Module 7, Group 2-Module 5, Group 6-Module 2, and Group 12-Module 2.
5) Several IV curves of the array were taken during the test (Appendix A). The IV data were normalized to 1000 W/m^2 and 45°C. A temperature of 45°C was used to closely represent the expected field performance.

Table 8. System 6 (Hoxan) System Performance

Curve Name	Measured Peak Power (W)	Measured Irradiance (W/m^2)	Measured Cell Temp. (°C)	Normalized Peak Power (W)
s5-iv07	3936.25	934.5	55	**4410.1**
s5-iv08	3926.93	934.2	55	**4401.1**
s5-iv10	3923.54	936.5	55	**4386.5**
Hoxan Average Normalized System Peak Power				**4399 W**

Control Room

The control room was in good condition (Figure 31). The ventilation fans were not operational at the time of the test, but the equipment appeared to be undamaged. The northwest side of the control room contained a DAS.

Figure 31. Control Room

A weather station (Figure 32), mounted on the control room, contains instruments for measuring wind speed, wind direction, ambient temperature, horizontal irradiance and irradiance on a tilted surface. These sensors will be removed by FPL and sent to FSEC for inspection and calibration.

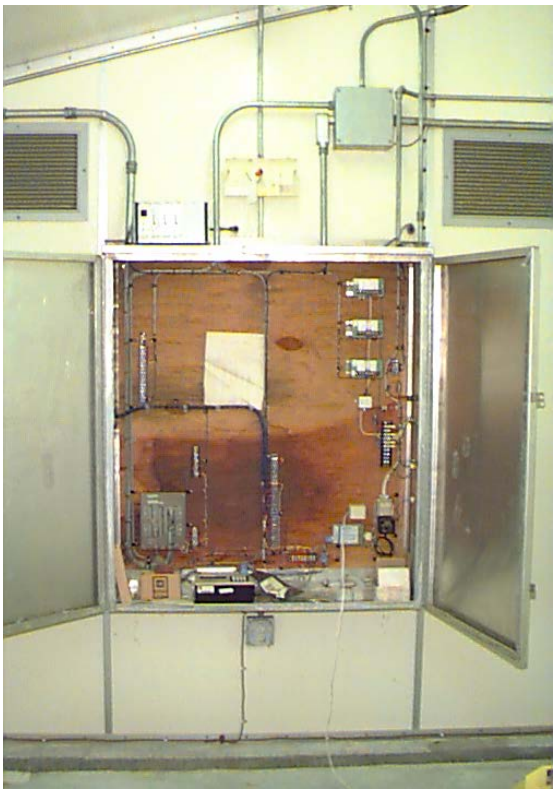

Figure 32. Data Acquisition System

RECOMMENDATIONS

The following repairs are recommended to provide a fully functional system. The repairs and suggestions are grouped into a general category applicable to the array field and into categories for each of the individual arrays.

General Conditions

- Replace all exterior junction boxes that have been corroded to prevent damage to the electrical components. Plastic or fiberglass enclosures are recommended for corrosion resistance.
- Bond all module frames and properly ground the array support structures to ensure safety for workers and to protect the equipment. Each module frame and the array support structures should be connected to a bare bonding conductor and then connected to earth ground. It is permissible to use multiple ground rods (for bonding).
- Remove several modules from each array for a comprehensive performance evaluation by Sandia National Laboratories. Tests will be conducted that will help determine the degradation mechanisms. This information will assist in the calculation of the array output that can be expected in the future.
- Overhaul the DAS by having the malfunctioning equipment repaired, calibrated, or replaced. It is important that data from the array be collected and analyzed to provide an accurate description of the systems' performance as a generation facility. A cellular phone should be installed for reliable data collection communications.
- Provide operation and maintenance (O&M) logs for each system. Update the logs any time repairs are required. Include a diagnosis of the problem and documentation of the maintenance procedures conducted.
- Conduct general maintenance inspections at least once per quarter to ensure proper function and for preventative maintenance scheduling.
- Initiate and maintain a monthly meter reading schedule to track performance.

System 1 – Sovonics

- Replace the conductors from the source circuit junction box to the combiner box in the control room. Identify the cause of the apparent ground fault in the existing conductors to prevent future occurrences.
- Replace the blown fuses in the Omnion inverter. Inspect the inverter for damage to the electronics or send the unit to the manufacturer for inspection. The inverter may need to be repaired, upgraded, or replaced, depending on the present condition.
- Test the degraded modules during the quarterly maintenance inspections to determine the effects of any electrical output changes on the output of the PV array. Take functioning modules from a single string to replace any malfunctioning modules.
- Replace the corroded source circuit junction boxes.
- Install proper bonding and grounding for the modules and array support structure.

System 2 – Mobil

- Replace the corroded source circuit junction boxes.
- Install proper bonding and grounding for the modules and array support structure.

- Test Module 6 (slight delamination was observed) and Module 4 (front contacts are corroded) during the quarterly maintenance inspections for output levels, and replace if necessary.

System 3 – Kyocera

- Replace the corroded array summing junction boxes.
- Install proper bonding and grounding for the modules and array support structure.

System 4 – Kyocera

- Replace the corroded array summing junction boxes.
- Install proper bonding and grounding for the modules and array support structure.

System 5 – ARCO

- Complete the installation of the system.
- A newer model inverter should be installed. The DECC inverter should be removed from the site and placed in a technological museum.
- Replace Module 7 – Group 10, which exhibits severe browning.
- Test and evaluate the modules with cracked cells and replace if necessary.
- Allow the modules to remain in a horizontal position and properly install bracing and tie downs. In a horizontal orientation, the system will have a higher output in the summer than in the winter in comparison with orienting the array tilted to the south. The horizontal position will also be more aesthetic as the browning of the modules will be less visible.
- Document the extent of the browning during quarterly maintenance inspections to identify any changes in the condition.

System 6 – Hoxan

Option 1

- Replace the severely corroded array support structure with a corrosion resistant structure.
- Orient the array facing south at an angle of 24 degrees from horizontal on the new mounting structure.
- Replace or repair the Abacus inverter.
- Install an ac disconnection switch at or near the inverter, or mount a sign clearly stating how to isolate the inverter.
- Test and evaluate the modules showing signs of corrosion or water damage and replace malfunctioning modules.

Option 2

- Disassemble the system and salvage the functioning modules, electronics, and BOS.
- Reuse the suitable components in other installation projects or displays.

APPENDIX A
ARRAY IV CURVES

APPENDIX B
ARRAY CONFIGURATIONS
and
MODULE SERIAL NUMBERS

ARRAY 1 (SOVONICS)
showing module serial numbers

005940	005789	005884	005730	005822	005734	005900	005798	005935	005775	005779	005919	005747	005727	005873	005928	005922	005754	005950	005952	005896	005746	005865	005859	005845	005794	005733	005955	005114	005743
005887	005786	005898	005732	005879	005917	005901	005787	005941	005831	005728	005923	005749	005883	005874	005925	005843	005757	005912	005916	005806	005807	005793	005861	005871	005765	005944	005956	005120	005751
005886	005948	005894	005808	005876	005834	005904	005809	005943	005855	005812	005918	005750	005882	005875	005910	005821	005829	005924	005752	005771	005803	005858	005862	005776	005802	005758	005961	005154	005839
005957	005860	005885	005804	005869	005838	005899	005929	005880	005766	005731	005915	005742	005881	005908	005819	005853	005794	005926	005748	005761	005891	005791	005823	005773	005805	005756	005813	00511?	005832
005939	005863	005892	005763	005868	005846	005801	005936	005893	005877	005729	005820	005811	005942	005907	005780	005736	005753	005911	005849	005769	005930	005792	005867	005740	005897	005741	005815	005115	005833
005797	005825	005795	005744	005841	005782	005906	005937	005837	005824	005796	005816	005755	005949	005958	005848	005854	005818	005953	005856	005785	005931	005799	005772	005783	005909	005768	005852	007126	005828

Tilt angle: 24°
Output: Unknown
Model: P-201
Date: Unknown
Type: Amorphous Silicon

ARRAY 2 (MOBIL)
showing module serial numbers

12740	12747	12912	12894	12745	12890	12578	12579	12736	12733	12852	12856	12735	12748	12738	12847	12743	12582	9556	12921

Tilt angle: 24°
Output: Unknown
Model: Ra180-36E
Date: 11/27/89
Type: Polycrystalline

ARRAY 3 (KYOCERA)
showing module serial numbers

90X14059	90X14058
90X14060	90X14059
90X14081	90X14056
90X14082	90X14057
90X14017	90X14060
90X14018	90X14063
90X14023	90X14064
90X14029	90X14024
90X14030	90X14011
90X14031	90X14012
90X14032	90X14047
90X14078	90X14048
90X14075	90X14053
90X14076	90X14054
90X14071	90X14072
90X14020	90X14013
90X14037	90X14014
90X14038	90X14079
90X14021	90X14080
90X14022	90X14001
90X14077	90X14002

Tilt angle: 23°
Output: 93.6 W/Module
66 Cells/ Module
Voc: 31.0 V
Isc: 3.02 A
Dimensions: 1195x655x36 mm
Model: LA661K94
Date: October 1990
Type: Polycrystalline

ARRAY 4 (KYOCERA)
showing module serial numbers

90X14083	90X14069
90X14084	90X14070
90X14056	90X14039
90X14055	90X14008
90X14058	90X14007
90X14046	90X14061
90X14068	90X14062
90X14015	90X14043
90X14065	90X14044
90X14066	90X14035
90X14049	90X14004
90X14033	90X14074
90X14025	90X14050
90X14005	90X14036
90X14006	90X14016
90X14009	90X14067
90X14027	90X14026
90X14028	90X14045
90X14041	90X14057
90X14042	90X14051
90X14040	90X14052

Tilt angle: 23°
Output: 93.6 W/Module
66 Cells/ Module
Voc: 31.0 V
Isc: 3.02 A
Dimensions: 1195x655x36 mm
Model: LA661K94
Date: October 1990
Type: Polycrystalline

ARRAY 5 (ARCO)
showing module serial numbers

WEST HALF

*	10005	10005	10005	10007	10002	10007	10005	10001	10001	10001	10004	10019	10003	10018	10022
*	10024	10015	10007	10026	10002	10014	10005	10001	10002	10000	10002	10027	10004	10006	10016
*	10014	10024	10024	10007	10002	10014	10006	10000	10002	10004	10002	10021	10012	10014	10020
*	10021	10024	10021	10005	10005	10005	10004	10000	10002	10004	10003	10005	10012	10008	10026
*	10023	10021	10021	10007	10000	10000	10006	10008	10008	10001	10002	10008	10007	10010	10015
*	10024	10024	10023	10002	10006	10000	10004	10003	10001	10003	10008	10006	10007	10016	10011
*	10024	10024	10014	10006	10014	10000	10004	10003	10000	10003	10004	10006	10008	10010	10006
*	10007	10015	10024	10007	10004	10014	10004	10001	10000	10003	10003	10006	10008	10015	10008

*Serial number unknown

EAST HALF

100227	10022	10027	10018	10729	10572	10906	10905	10017	10022	10020	10017	10017	10009	10010	10008
100252	10023	10023	10025	10721	10580	10591	10906	10017	10023	10020	10015	10017	10011	10012	10009
100220	10022	10022	10022	10700	10716	10579	10901	10017	10023	10020	10015	10009	10011	10012	10010
100275	10027	10027	10025	10012	10010	10018	10019	10018	10015	10020	10018	10009	10002	10011	10010
100136	10013	10013	10013	10021	10016	10019	10018	10025	10020	10016	10020	10011	10010	10011	10009
100257	10025	10017	10017	10013	10012	10019	10018	10025	10015	10016	10020	10009	10010	10011	10009
100233	10023	10025	10024	10012	10012	10019	10018	10025	10020	10016	10019	10017	10009	10011	10009
100228	10022	10027	10027	10013	10012	100?	10018	10025	10015	10016	10019	10017	10008	10011	10009

Tilt angle: 0°
36 Cells/Module
Output: Unknown
Model: M52-S
Date: 05/83
Type: Single Crystal

ARRAY 6 (HOXAN)
showing module serial numbers

34161	34946	34949	34288	34196	34931	34173	33958	34170	33938	33972	34305	33961	33971	33939	33991
34283	34157	34280	34156	34134	34303	34226	34293	34282	34292	33973	34034	33993	34168	33934	33926
34033	34290	34285	34172	34300	34032	34199	34171	33948	33953	34294	33954	34297	34304	33945	34164
34967	34965	34301	34195	34289	34952	33925	33990	33963	33959	33928	33927	33929	34286	34132	33936
34198	34163	34951	34302	34295	34174	33957	33974	33956	34130	33964	33966	33962	33968	33933	34133
34158	34299	34169	34166	34167	34155	34228	34162	33932	33992	33930	34287	33947	34159	34165	33937
34031	34197	34131	34296	34298	34160	34307	33960	33955	34284	33969	33970	34281	34030	33950	34227

Tilt angle: 25°
36 Cells/Module (4x9)
Output: Unknown
Model: H-4810
Date: Unknown
Type: Single Crystal