FLORIDA SOLAR ENERGY CENTER®

EVALUATE DEPLOYMENT OF PHOTOVOLTAIC SYSTEMS FOR DISASTERS

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EVALUATE DEPLOYMENT OF PHOTOVOLTAIC SYSTEMS FOR DISASTERS

Final Report

FSEC-CR-1236-01

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Submitted by:

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EVALUATE DEPLOYMENT OF PHOTOVOLTAIC SYSTEMS FOR DISASTERS

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FINAL REPORT

EVALUATE DEPLOYMENT OF PHOTOVOLTAIC SYSTEMS FOR DISASTERS

Florida Solar Energy Center

1.0 INTRODUCTION

Hurricanes, floods, tornados, earthquakes and other disasters destroy all types of buildings, structures, and vegetation. Disasters such as these can leave millions of people without electrical services, functional water and sewage systems, and medical services for days and weeks in their aftermath. Appropriately sized, battery-equipped solar systems can provide almost inexhaustible electrical power, making them a valuable resource for mitigation efforts following these catastrophic events.

Photovoltaic (PV) systems are used in recovery efforts to supply security lighting in key locations and to supply power to radios, lights, fans, and vaccine refrigerators in medical clinics. These solar generators can provide quiet, pollution-free electrical power for almost any type of electrical equipment. They are modular so they can be combined into larger systems. They can be portable, stand-alone systems or integrated into a building to interact with utility grid power.

Since 1992, the Florida Solar Energy Center (FSEC) has responded to hurricanes using PV systems to provide electrical power. FSEC has gained extensive knowledge and experience in analyzing disaster related needs and developing disaster equipment. FSEC also has procured, maintained, and deployed PV-powered equipment for use in post-disaster recovery efforts and mitigation activities. Their knowledge has been transferred to government agencies, the PV industry, and disaster relief organizations in Florida through training programs. This project represents a further application of FSEC's expertise in this field.

This final report summarizes work performed for the contract entitled "Evaluate Deployment of Photovoltaic Systems for Disasters" during the period from September 22, 2000 through May 31, 2001. The purpose of this U.S. Department of Energy (DOE) funded project was to visit the site of each mobile photovoltaic generator deployed at the Federal Emergency Management Agency (FEMA) depots to evaluate their performance and physical condition, and determine the viability of their use disaster relief efforts. The goal of the project is to promote the use of mobile PV-generators in disasters.

2.0 PROJECT OVERVIEW

In 1996, the U.S. Department of Energy, through the Atlanta Regional Office (ARO), developed a program with the Federal Emergency Management Agency to provide photovoltaic electrical power in disasters. DOE and FEMA joined in a partnership and interagency agreement to utilize efficient and renewable energy technologies for making communities more resistant to the damaging effects

of natural disasters. In support of this effort, DOE-ARO purchased eight mobile PV-generators with funds from the Federal Energy Management Program (EERE). The units, which were constructed in 1998 by two different companies, were supplied to FEMA for deployment in disaster response efforts.

Figure 1 APC unit at FSEC

Figure 2 SunWize unit at FSEC

The mobile generators consisted of a PV system installed on a commercial trailer. The design of the two models purchased differed slightly. Applied Power Corporation (APC) used a pole mount for the 384 Watt PV panel on model PPS-500 (Figure 1); whereas, a split fixed mount supported the 1800 Watt PV panel on SunWize's model PS-01 (Figure 2). Both mobile generators were designed to provide 120 VAC. In addition, they can operate in a stand-alone mode as a portable power source, or in buildings-integrated applications as utility backup power. The manufacturers' specifications for these models are included in Appendix B and summarized in Table 1.

Table 1. PV-generator trailers specification

	APC Model PPS-500	***SunWize Model PS-01***
PV size	384 Wp @12 VDC	1800 Wp @ 24 VDC
PV array	6 modules parallel	24 modules w/ 2 in series string
Battery	12 VDC @490 AHr	24 VDC @ 1050 AHr
Inverter	Mod-Sine - 1500 W	Sinewave - 4000 W
Trailer	4' x 6' w/ 1 axis @ 1900 lb	7' x 15' w/ 2 axes @ 4400 lb

In 1999, FEMA determined the best use for these mobile PV generators was in response to hurricanes, and placed them in four depots along the southeastern coast of the United States and Puerto Rico. Each location received one APC model PPS-500 and one SunWize model PS-01 for a total of eight units. The original locations were as follows:

Emmitsburg, Maryland, Region III
Berryville, Virginia, Region III
Denton, Texas, Region VI
San Juan, Puerto Rico, Region II

The locations of the mobile PV generators were subsequently changed by FEMA representatives to better meet their needs. Two units originally shipped to FEMA headquarters in Hato Rey, Puerto Rico (Figure 3) in August 1999 were moved to Maunabo in March 2000 (Figure 4). Also, in September 2000, the two units at the Mount Weather site in Berryville, Virginia were moved to Emmitsburg, Maryland. The final locations of all eight units, along with their identification numbers, are shown in Table 2.

Figure 3 Port at Fort Lauderdale

Figure 4 FEMA depot in Muanado

The addresses of the three final locations are as follows:

Federal Emergency Management Agency
Edificio CFI, #5
Carretean Rd#3, Barrio Vista Alegre
Salida Para Yabucoa
Maunabo, Puerto Rico 00707

Federal Emergency Management Agency
National Emergency Training Center
16825 S. Seton Avenue
Emmitsburg, Maryland, 21727

Federal Emergency Management Agency
Emergency Operation Center, Region VI
FRC 800 North Loop 288
Denton, Texas, 76209

Table 2. Unit Identification Numbers and Location

UNIT ID#	*LICENSE TAG #*	*MANUFACTURER*	*LOCATION*
1	E53912	SunWize	Emmitsburg
2	E53910	SunWize	Denton
3	E53911	SunWize	Emmitsburg
4	E53913	SunWize	Puerto Rico
5	E53916	APC	Emmitsburg
6	E53914	APC	Puerto Rico
7	E53915	APC	Denton
8	E53917	APC	Emmitsburg

Evaluation of the deployment of these systems for disaster relief was completed in two steps; (1) an on site inspection of the mobile PV generators and (2) interviews with FEMA personnel responsible for the systems. A site evaluation form was developed to record information on the location of the units, contacts, present state of operation, maintenance, past and present use, and viability interviews (see Appendix A). Repair information was recorded on a maintenance form provided by SunWise. Bill Young, an FSEC engineer with previous experience with these units, conducted the evaluations, as well as on-site training of FEMA personnel where appropriate.

Jim Powell and David Waldrop (DOE-ARO) and James Grichar (FEMA) were instrumental in developing of the original program and providing contact information on the FEMA personnel responsible for the units at each site. There were originally four sites to visit in three different states and one U.S. territory outside the continental U.S. An initial visit to Mount Weather and the

National Emergency Training Center was made just before the contract began. Table 3 shows locations, dates and contact persons for each site visit.

Table 3. Site Visits

LOCATION	*DATE(S)*	*CONTACT(S)*
Berryville	09/01/00	Mike Johnson
Puerto Rico	10/28-31/00	Miguel Paganmir 787-296-3500/fax 3642 Pedro Rivera 787-861-0042 Jose Bravo 787-296-3555 Reinaldo Colon Tito Garabis Carlos Sancaez, DOE-PR 787-724-8774/fax 721-3089 Rurico Diaz, DOE-EM Inocencio Rodriguez DOE-EM
Emmitsburg	04/07-15/01	Ron Face 301-447-1223/ fax 1052 Tom Pitotti 301-447-1234 Perry Joy 301-447-1414 Steve Watkins Deb Coshum
Denton	04/30 - 5/01/01	Ed Harris 940-898-5101/ fax 5230 John Hyatt 940-898-5223/ fax 5512 Craig Timsman 940-898-5183 Tracy Stokes

3.0 RESULTS

As previously mentioned, the evaluations were completed in two steps; (1) on site inspections of the mobile PV generators and (2) interviews with FEMA personnel responsible for the systems. A site evaluation form was developed to record information on the location of the units, contacts, present state of operation, maintenance, past and present use, and viability interviews (see Appendix A). Repair information was recorded on a maintenance form provided by SunWise. An FSEC engineer, with previous experience with these units, conducted the evaluations and on-site training of FEMA personnel when appropriate.

3.1 System Evaluation

Once on site, contact was made with FEMA representatives responsible for the units, and a site evaluation was conducted. The FEMA representatives were interviewed first about present physical location and operating status of the units. Then, information about past and present use was obtained. Next, FEMA deployment procedures and on-going operation of the units were discussed. FEMA representatives were then questioned regarding the viability of future use of these mobile PV generators in disasters. Following the interviews, the units were inspected to determine their present physical condition and state of operation. Information on previous maintenance and repair activities was collected. Evaluation information was recorded using the form in Appendix A.

Manuals on the units provided a hardware description and a list of output characteristics that could be visually inspected or measured with simple instruments. A simple test kit was constructed to verify operation and make measurements. The kit included a multi-meter for voltage, current and resistance measurements, a pyranometer to measure the sun's intensity so the current output of the PV modules could be checked, and appliances to check the operation of the inverters such as lights and a drill. Incandescent and flourescent lamps of various sizes and types provided resistive and electronic loads. Lamp sizes varied from 5 to 250 watts, and were plugged into a receptacle which allowed up to 800 watts to be connected at one time as shown in Figure 5. A drill provided a 1/12 horsepower inductive load for testing. The kit also included a few screw drivers, wrenches, wire cutters, pliers and other tools to provide access to components and make minor repairs when needed.

Figure 5 Invertor load test

The operation of each unit was visually inspected and tested, and results were recorded on the forms in Appendix A. The whole mobile PV generator was inspected including the tires, PV modules,

batteries and inverters. The inspection also included the observation of values on the charge controller and inverter displays. The enclosures were opened to inspect for loose terminals, corrosion, bugs, and water damage. The charge controller and inverter displays were read and data was recorded. The battery pack, PV and inverter voltages are included in Table 4.

Table 4. Voltage readings

Unit ID #	*Battery Voltage*	*PV Voltage*	*Inverter Voltage*
1	24.8	25.2	119.5
2	26.8	27.0	121.0
3	26.0	25.2	0
4	26.5	25.8	120.1
5	13.6	14.1	120.0
6	13.8	14.3	120.2
7	14.2	14.9	121.0
8	13.7	14.2	119.5

The output of the inverters was tested using the lamps starting with a 5 watt lamp and increasing in wattage until all the lamps were used. This procedure tested the low wattage turn-on operation of the inverters and ramped the inverter output to nearly half of the inverter's rating. The inverter's operation with an electronic load was tested by use of only flourescent lamps with an electronic ballast. The drill tested the operation of the inverter with inductive loads. The inverters passed the test and operated as expected except for the one failed inverter in Unit #3.

All of the PV systems operated as AC power generators except one of the SunWize units, which had a failed inverter. Some units required minor repairs before they were fully operational as described in section 3.2. Structural problems were found with the APC trailers that would probably prevent them from being deployed in a disaster. The APC units were operational, but only where they were currently stationed. The deployment capability of the trailers at the time of evaluation is summarized in Table 5.

Table 5. Trailer Status

Unit ID #	*Deployment status*	*Condition*
1	operational	
2	operational	broken cover, temporary fix
3	not operational	inverter failure, needs repair
4	operational	
5	questionable	broken trailer brace, temporary fix
6	questionable	broken trailer brace
7	questionable	broken trailer brace
8	new stationary	broken trailer brace, no PV system

3.2 Maintenance and Repairs

The simple tool kit, previously discribed, was taken to make minor repairs, such as loose bolts or wires, or replacement of broken covers After inspection some minor and a few major problems were found. Problems with the units varied from electrical, to mechanical, to structural, to others caused by forces of nature. Minor repairs were made to some of the units following the evaluation. Major repairs were not made since that effort was not part of the contract and because additional tools and machine shop equipment would be needed. For example, a broken trailer frame was not repaired because welding equipment was needed in addition to parts that could not be obtained at a local hardware store. The age old problem of rust effected all of the units. Those located near the ocean suffered the most. Some temporary minor fixes, such as painting rust spots and fixing the outlet covers, were performed. Table 6 summarizes the problems found with the units.

All wire connections were checked and loose connections were tightened. There were no signs of corrosion at any wire connections. Minor rust repairs were made to all rusty cabinets by sanding and repainting the spots, but rust on the trailers was not repaired since no major rust was found.

Some FEMA representatives collected data on the operation and maintenance of the units at their site. These data show the units operated as expected. Some performance data on the units at the Denton and Emmitsburg sites are included in Appendix D. The FEMA representatives in Emmitsburg replaced one of the PV modules that failed in one of the SunWize units, when the glass cover shattered.

Table 6. Maintenance Summary (Present trailer numbers/ * indicates fixes)

Unit ID #	*PV system*	*Broken*	*Rust*	*Water*	*Trailer*
1					
2	loose wire-combiner/battery *	outlet cover*			
3	loose wire-combiner*	inverter		cabinet puddle	
4			cabinet*	cabinet puddle	
5		floor bracket	cabinet*	rotten floor	exchanged*
6		floor bracket	cabinet*	rotten floor	
7		floor bracket	cabinet*	rotten floor	
8		floor bracket	cabinet*	rotten floor	abandoned

3.2.1 SunWize Trailers

Two of the SunWize units had some loose wires in the combiner box and/or battery box. The combiner boxes had two to four loose wire connections in the PV strings, which limited current but did not prevent the systems from operating. In Denton, a loose battery connection was found in one of the strings, but didn't cause any problems due to its location in the circuit. Also, the system was not being used.

An inverter was not operating in one of the SunWize units in Emmitsburg. It had a red LED error light and an error message of "Heat Sink Over Temperature." Arrangements were made with Trace Engineering to have the inverter repaired. Later, the inverter was sent to the manufacturer for repair by FEMA support personnel. The inverter was repaired and reinstalled making the trailer operational again.

One unit's AC power outlet cover was broken off. A piece of plastic was taped over the cover of the outlet box as shown in Figure 6, since the proper cover could not be obtained locally. A new cover was in the process of being located, but these covers are not typically stocked. If one cannot be found, then the complete outlet box should be replaced.

Figure 6 Repairing power outlet cover in Denton unit

Two of the units had electrical cabinets with small puddles of water inside on the floor of the cabinet. It was difficult to determine the source of the water leak without proper equipment. In Puerto Rico, the electrical cabinet was getting rusty along the edge of the doors, as shown in Figure 7.

Figure 7 Rust on cabinet doors on Puerto Rico unit

3.2.2 APC Trailers

Permission was obtained to display one of the Emmitsburg units at the National Hurricane Conference in Washington, DC during the same week as the site evaluation. One of the smaller units was chosen, since it would be easiest to transport to the conference. After inspecting the units, the PV system on trailer 8 was found to be falling through the floor, and trailer 5 showed similar floor damage. The wood making up the floor of the APC trailers was rotting, as shown in Figure 8 and

Figure 9. The metal braces that support the wooden floors were breaking away from the frame structure of the trailer, as shown in Figure 10. The system enclosure box was sinking into the rotten wood and pushing down the braces that had broken loose to a position below the main trailer frame, as shown in Figure 8. The paint on the floor was peeling off, and the wood did not appear to be hardwood or pressure treated wood. Also, note the rust on the APC trailer system enclosure in Figure 8.

Figure 8 Enclosure sinking into wooden floor

Figure 9 Paint peeling off

Figure 10 Floor brace breaking away

Figure 11 Temporary floor fix

The previous year, the PV system on unit # 5 was removed from the trailer and placed on a platform in front of the Dining Hall. The trailer was then placed in storage. Unit # 8 was being used to power the Burn Building Complex. Trailer # 5, in storage, was in the best condition so the PV system on trailer # 8 was relocated to trailer # 5 for the trip. A temporary fix was made to trailer # 5 by placing metal bars under the enclosure to strengthen the flooring so the enclosure would not fall through as

shown in Figure 11. The new system constructed from PV system # 8 and trailer #5, then traveled 75 miles to the conference where it was displayed for three days and returned to Emmitsburg. It should be noted that, since PV systems on trailers # 5 and # 8 have been exchanged, trailer # 8 no longer has a PV system mounted on it. Since then, FEMA has replaced the wood and repaired the frame on Trailer # 5.

3.3 Viability

These mobile PV generators were designed by two different companies, each with their own implementation concept. Each of the two designs provided different energy production capability. Also, each design had differently sized of photovoltiacs and inverters mounted on-board. The physical size of the trailers were also different. Specifications defining these units was obtained from their manuals and provided in Appendix B. Both units have batteries to operate in stand-alone mode and inverters to output 120 VAC electrical power. This allows the trailers to be operated in a disaster to supply electrical power in the same way a conventional gasoline/diesel generator would.

FEMA representatives at each site were interviewed regarding their opinion on the viability of the use of the mobile PV generators in disasters. The Denton FEMA representatives expressed concern that the trailers did not fit the applications they are called on to power during a disaster. They explained that the AC generators they provide are from 25 kw to 150 kw of electrical power, as shown in Figure 12, which dwarfs the capability of these units. Their conventional gasoline/diesel generators are used for emergency operation centers, hospitals, treatment plants, and other similar large facilities in order to restore full operation of the facilities. The generators they provide are in support of FEMA operations and some requests of local governments. These mobile PV generators, according to Denton representatives, would be most useful for small, long-term operations by disaster relief groups, but not FEMA operations directly.

Figure 12 50 kW diesel generator in Denton, Texas

The Emmitsburg and Puerto Rico FEMA representatives explained that the viability of the units' use in disasters depended on the user and the application. They felt disaster relief organizations would find the mobile PV generators useful for small temporary shelters, clinics, communications, comfort stations, special operations, and special needs support. Also, the units would be most useful for organizations such as Amateur Radio, Salvation Army, church support groups, and Habitat for Humanity. The APC units' power output was too small for most disaster applications, except amateur radio communication. Whereas, the larger SunWize units' output was useful in more applications for disaster organizations.

The APC unit was easy to tow by most vehicles. The SunWize unit, on the other hand, was heavier and had to be towed by large trucks, thereby, limiting its use because of the difficulty of transporting it. When shipping, the large physical size of the SunWize unit took up most of a semi-trailer truck, air transport, or cargo container on a ship.

Some of the mobile PV generators were used immediately after purchase from the manufacturer, and before being placed at FEMA facilities. The first units were used for two disasters and one training exercise as follows:

Hurricane Bonnie by North Carolina Solar Energy Center
Hurricane Georges by Miami Catholic Charities
Military field training exercises by the U.S.Army's 82nd Airborne Division

Figure 13 Special needs application

Figure 14 Special needs application

One of the early users of the units was the North Carolina Solar Energy Center after Hurricane Bonnie struck the shores of North Carolina. In August of 1998, two of the units were transported to Knotts Island where they were used for several days to power two homes for special-needs people, as shown in Figures 13 and 14. The people living in these homes required medical life support equipment for their illnesses, making them difficult to move to a new location during an evacuation or even after the hurricane when the utility power was out. The mobile PV generators allowed these

people to stay in familiar surroundings and receive the medical treatment they needed, while not being a burden to local shelters.

Figure 15 Mobile PV generator at a distribution center

Figure 16 Donated supplies for distribution

When Hurricane George struck Key West, Florida, in September of 1998, FSEC and Catholic Charities of the Miami Diocese requested the use of two mobile PV generators. A SunWize unit was used at a disaster relief distribution center in Miami to power an abandoned building that Catholic Charities was using to collect and distribute food, clothes and other donated goods, as shown in Figure 15, and 16. Figure 17 shows some PV-powered office equipment used at the distribution center to record and control donations. The other unit was used in a joint effort with Habitat for Humanity on Big Pine Key Island. The APC unit supplied the electricity for lights and power tools used in repairing low income homes. Figure 18 shows the unit at St. Peters Catholic Church were it was stored each night.

Figure 17 Office equipment powered by PV

Figure 18 Unit stored at St. Peter's Church

One of the first sets of mobile PV generators received at Emmitsburg, made by SunWize, and was used to power exhibits at an event held in Washington, DC. Since 1999, FEMA personnel in Emmitsburg have been using the units in their daily operations, and as a live PV demonstration for attendees at the training center. A SunWize unit was then stationed outside of the NFA Classroom (Building J) near the break room, as shown in Figure 19. The PV system was hardwired into the building to a power panel for the soda machines in the break room, as shown in Figure 20. The soda machine provides a small constant load within the capabilities of the unit's design. The first APC unit was stationed outside the Dining Hall (Building K), as shown in Figure 21. There the PV system was hardwired into a power panel in the building to run a computer for the Emergency Managers Weather Information Network (EMWIN) display, as shown in Figure 22.

Figure 21 Dining hall PV system

Figure 20 PV powered soda machine, note the plack.

The second set of units to arrive at Emmitsburg were also put to use at the facility. The second SunWize unit was stationed with the first SunWize unit to provide additional power for the soda machines. The second APC unit was stationed at the Burn Building Facility (Building U), as shown in Figure 23. Previously, a gasoline generator was transported to the site during training exercises to power monitoring equipment and fire systems. Now the APC unit powers the facility on a permanent basis and refueling is no longer required.

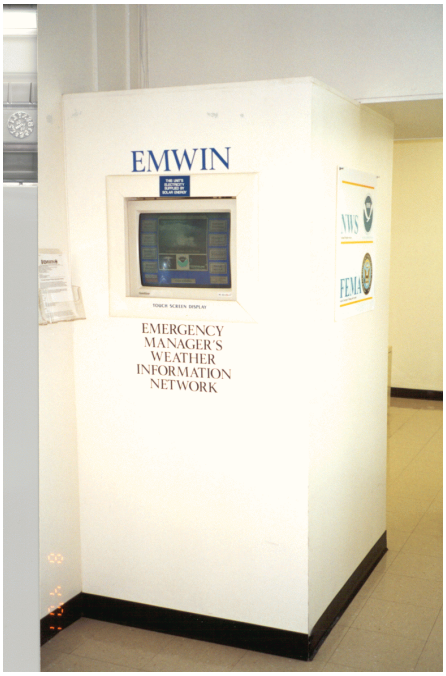


Figure 22 EMWIN powered by PV

Figure 23 Burn building complex PV system

After the mobile PV generators arrived in Denton, the APC unit was transported to St. Louis and used at an exhibit for an event held for the Pope when he visited the Catholic Church. There is also a plan to have the existing sign at the entrance to the facility replaced with a new one. At that time, the SunWize unit may be placed near the entrance to power the new sign. Presently, the units are not being used at the facility, and are stored in the front parking lot for people to see.

3.4 Training

Minor training was conducted during site evaluations for some of the FEMA personnel responsible for the mobile PV generators. The amount and type of training was based on each individual's knowledge and experience. Some representatives were very knowledgeable of PV, while others had never heard of it before. Formal training classes were not conducted at any site. Rather, training consisted of one or more activities on the following list:

Hardware overview
Concept overview
PV literature overview
Trailer manual overview

Some representatives did not have manuals for the units, so copies were located and provided. A representative at each site was provided with educational literature on photovoltaics (see Appendix (C) along with information on formal PV training courses they could attend. Representatives were encouraged to attend various conferences to gain formal training on PV, or to attend one of FSEC's PV training courses. The hour or two available during the site visit was not enough time to complete formal training.

At each of the three sites, there is at least one person knowledgeable in PV as well as the operation of the units who could properly and effectively use them. The Puerto Rico site had a DOE representative assigned to support FEMA with the mobile PV generators and any energy needs in a disaster. On October 29, 2000 during initial delivery of the units to Puerto Rico, six members of FEMA and DOE were trained at FEMA headquarters in Hato Rey, as shown in Figure 24. The Emmitsburg site is located near the Solarex Corporation, which has provided technical assistance in the past. But, no one there was directly assigned to assist FEMA.

If disaster support organizations were aware of mobile PV generators and their availability, the units would get more use. The successful applications noted in this report were largely due to experienced users who know how to apply the units to a need. The real need for education is with the disaster support organization that could use them and an outreach program to make them aware of the units' availability.

Figure 24 PV trailer and students at FEMA headquarters in Puerto Rico

The following table lists the major accomplishments of the project and the time of successful completion.

Item	*Activity*	*Description*	*Completion date*
1)	Milestone	Trip to Puerto Rico	10-28/31, 2000
2)	Milestone	Trip to Emmitsburg	04-7/15, 2001
3)	Milestone	Trip to Berryville	9-1-2000
4)	Milestone	Trip to Denton	04-30 to 5-1, 2001
5)	Deliverable	Final Report	07-31, 2001

Table 6. Schedule of Milestones and Deliverables

The Final Report was the only deliverable for this program listed in the schedule. All research, analysis, activities and findings were reported.

4.0 CONCLUSIONS

Overall, the trailers and PV systems were in good condition, and showed acceptable reliability and quality. Most problems were minor and fixable. Even major problems could be fixed in the field. Proper periodic maintenance would eliminate most problems. Both models had their own inherent problems related to electrical, mechanical, structural and the forces of nature as noted in Table 5. Some minor problems were fixed at the time of this evaluation, but rust and corrosion are continuous problems. The units originally had a manufacturer warranty, which had since expired. Consequently, they were not under any programmed maintenance or technical support agreement by the manufacturers. FEMA is preforming some maintenance and repairs as their time and resources allow. To be fully operational during hurricane season or any other type of disaster, they need to have periodic maintenance and repairs. This requires dedicated oversight and education.

One problem was water leaking into the SunWize power cabinets, possibly through the doors or the conduit penetrations. The SunWize units had more PV modules and batteries, and used a combiner box for some of the connections; therefore, there were more wiring connections that needed to be maintained. The rotting wood floors of the APC trailers were a major problem, making travel with these unsafe. A temporary fix prevented the electrical enclosure from breaking through the floor.

At the completion of all of the site visits, only one of the eight units was not operational and one was not deployable. The SunWize unit with the broken inverter was fixed a short time after the visit. The four SunWize units were capable of being deployed at this time. The other four units were operational and could be fixed for deployment by next hurricane season. Even though some of the units were being used for demonstration purposes, they could be disconnected from their demonstration application in less than an hour. A formal plan needs to be developed for their dedicated deployment and use.

Most of the mobile PV generators were being used for some real life application at their respective depots, thereby proving their viability as sources of electrical power. For example, one unit in Emmitsburg was used to replace a gasoline generator in periodic testing at the Burn Building. This eliminated the need for refueling the fossil fuel generator. Another PV generator provided power

for a soda machine. While this is not a critical load application, refrigeration of food is important to good health, as would be refrigeration medical supplies like vaccines at a clinic in a disaster application. Computer systems, whether for information services or for data operations, can be critical needs. The PV powered EMWIN computer system provides such an example.

These mobile PV generators have on-board battery storage and produce utility-grade power, allowing them to operate as an uninterruptible power supply for continuous power. They can operate in utility interactive mode when integrated into the power system of a building. These PV-generators provide a quite, environmentally benign, inexhaustible source of electrical energy. The 1.5 and 4 kW inverters provide enough 120 VAC power for most tools, equipment and appliances used in response and recovery. These units operate best for applications requiring continuous use of a known small load for a specific application. Their quiet, non-polluting operation is important at medical clinics where people may already suffering from trauma. They can also be used for mitigation efforts when integrated into a building power system for critical needs as shown in the distribution center example. The SunWize units are larger and more difficult to deploy, but are more useful in a disaster due to their larger power output. The APC units are easier to deploy, but meet fewer disaster power needs. However, both are useful in selected applications.

In conclusion, these mobile PV generators represent a viable alternative for use in disaster response and recovery. This report provided many examples of applications for their use by emergency response organizations in their operations. Future deployment depends on the level of awareness and understanding of personnel in disaster organizations, regarding their availability, utility, operation and maintenance. Mobile PV-generators have been successfully used in the past and will be successfully used in the future with proper education and support of these personnel.

APPENDIX A

Site Evaluation Forms

Site Evaluation Form

DOE – Evaluate Deployment of Photovoltaic Systems for Diasaters
Florida Solar Energy Center
10-20-2000

1. Date of Visit:

2. Site Location:

Address:

3. Contacts: Phone:

4. Trailer Identification:

1. 2.

5. Trailer Status:

Being used:

1. 2.

Present Working Status:

1. 2.

Maintenance Done:

1. 2.

Broken Parts:

1. 2.

6. Trailer Repairs:

Past Repairs:

1. 2.

Present Repairs:

1. 2.

7. Viability:

Trailer 1.

2.

8. Evaluation Completed By:

Site Evaluation Form

DOE-Evaluate Deployment of Photovoltaic Systems for Disasters
Florida Solar Energy Center
10-20-2000

1. Date of visit: Sept 1, 2000 FEMA - Reg III

2. Site Location: Berryville, Md Mount Weather

Address: _____

_____

3. Contacts: _____ Phone: _____

_____ _____

4. Trailer Identification: Trailers not there

1 _____ 2. _____

5. Trailer Status: Sent to Emmitsburg

Being used:

1. _____ 2. _____

Present Working Status

1. _____ 2. _____

Maintenance Done:

1. _____ 2. _____

Broken Parts:

1. _____ 2. _____

6. Trailers Repairs:

Past Repairs:

1. _____ 2. _____

Present Repairs:

1. _____ 2. _____

7. Viability:

Trailer 1. _____

2. _____

_____ _____

9. Evaluation Completed By: _____

Site Evaluation Form

DOE-Evaluate Deployment of Photovoltaic Systems for Disasters
Florida Solar Energy Center
10-20-2000

1. Date of visit: 10/28/00

FEMA - Reg II

2. Site Location: Maguadas, PR

Address: Edificio CFI #5 Carretean 3, Barrio Vista Alegre
Maunabo, PR 00707
Fax 721 3087

3. Contacts: Eugene Rodriguez DOE
Carlos Sanchez DOE Phone: 787 724 8774 x4015
Miguel Paganmin EM 787 729 7633
Rifrico Diaz DOE
EM - Petro Rivera

4. Trailer Identification:
1 Sunwize #4 E53913 2. APC #6 E53914

5. Trailer Status:

Being used:
1. NO 2. NO

Present Working Status
1. op 2. op

Maintenance Done:
1. remove rust & paint 2. Remove rust & paint

Broken Parts:
1. 2. rotten wood floor & broken floor brace in frame

6. Trailers Repairs:

Past Repairs: Repaired one year before
1. homeless took wire & 2.
Present Repairs: was rebuilt before PR
1. Fix some rust on control cabinet 2. fix some rust on control cabinet

7. Viability:
Trailer 1.
2.

9. Evaluation Completed By: BY

Site Evaluation Form

DOE-Evaluate Deployment of Photovoltaic Systems for Disasters
Florida Solar Energy Center
10-20-2000

1. Date of visit: _____

2. Site Location: Emmitsburg, Md - FEMA National Emergency Training Center

Address: 16825 S. Seton Ave Region III
Emmitsburg, Md 21727

3. Contacts: Ron Face Phone: 301-447-1223F1052
Tom Pitotti 301-447-1234

4. Trailer Identification:
1 Sunwize #1 E53912 2. Sunwize #3 E53911 * new
3 APC #5 E53917 4 APC #5 E53916

5. Trailer Status:
Being used:
1. yes 3 yes 2. yes 4 yes
Present Working Status
1. operational op 2. NO op
Maintenance Done:
1. PV combiner wire loose NA 2. N. Brace Trailer
Broken Parts:
1. ~~None~~ ~~None~~ 2. inverter Trace trailer Overtemp Error Trailer

6. Trailers Repairs:
Past Repairs:
1. PV Module Replaced 3 2. _____ 4
Present Repairs:
1. fiber wires 2. None
~~None~~ System 5 → 8 Trailer

7. Viability:
Trailer 1. _____
2. _____
3
4

9. Evaluation Completed By: Bill Young

APC #8 E53917

MAINTENANCE REPORT

Site	Date	Report Number
Emmitsburg Md	4-9-08	

Type of Maintenance: ☐ Scheduled ☒ Unscheduled ☐ Emergency repair

Event description: evaluation & site visit for DOT

Action Taken: ☐ Adjustment ☐ Test ☑ Repair ☐ Replacement ☒ Inspection

Notes: Floor boards of trailer are rotten and bracket holding them and brake hose from trailer Frame so trailer E53916 was traded to Gaithersburg & and steel bars were put on wood floor to support PV System

Subsystems involved: ☐ Array ☐ Battery

☐ Controls/switches ☐ Generator

☐ Other: ☒ Structure

So #5 = E53917

Problem Occurred: rotten wood & brake hose bracket
Date: _____ Time: _____

Action completed
Date: _____ Time: _____

System Off-Line? ☐ Yes ☐ No

Downtime hours: ____

Parts Replaced: Trailers traded System #5 → E53917

Labor: Repair hours: 1 Crew Size: 4 Man-hours: 4

Status: Work Complete? ☐ Yes ☐ No

Notes: _____

Report Completed by: BJ

APC #5 E53916

MAINTENANCE REPORT

Site	Date	Report Number
Emmitsburg Md	4-9-01	

Type of Maintenance: ☐ Scheduled ☒ Unscheduled ☐ Emergency repair

Event description: evaluation & Site visit for DOE

Action Taken: ☐ Adjustment ☐ Test ☒ Repair ☒ Replacement ☒ Inspection

Notes: this trailer was orginally install at Colfaxton and this load trailer removed from PV System and put on Blocks

Subsystems involved: is off

☐ Array ☐ Battery ☐ Controls/switches ☐ Generator ☐ Other: ☐ Structure

Problem Occurred: wood on trailer floor is rotten and bracket is broken off from that holdes floor

Date: Time:

Action completed Date: Time:

System Off-Line? ☐ Yes ☐ No Downtime hours:

Parts Replaced: trailer was removed and put on system #8

Labor: Repair hours: 2 Crew Size: Man-hours:

Status: Work Complete? ☐ Yes ☐ No

Notes:

Report Completed by: Bill Y

Trailer #3

SunWize Technologies, Inc. ES3911 G628089 From Benicia

MAINTENANCE REPORT

Site	Date	Report Number
Everett MD FEMA	4-9-01	

Type of Maintenance: ☒ Scheduled ☒ Unscheduled ☐ Emergency repair

Event description: evaluation & site visit for DOE

Action Taken: ☐ Adjustment ☐ Test ☐ Repair ☐ Replacement ☑ Inspection

Notes:

Subsystems involved: NOT working

☐ Array ☐ Battery
☐ Controls/switches ☐ Generator
☒ Other: Inverter ☐ Structure

Problem Occurred: Inverter
Date: 4-9-01 called Trace-Dean
Time: 11 am

Action completed: wont come ON red error LED Heatsink overheat
Date:
Time:

System Off-Line? ☐ Yes ☐ No

Downtime hours:

Parts Replaced:

Labor: Repair hours: Crew Size: Man-hours:

Status: Work Complete? ☐ Yes ☐ No

Notes:

Report Completed by: BY

SunWize Technologies, Inc. E5391 G 628089

BATTERY LOG SHEET
Sealed Lead-Acid Batteries

Cell no. 1 is the cell that is connected to the main battery negative lead (black).

Date	4-9-01							

Cell #	V	V	V	V	V	V	V	V
1	13.13							
2	13.1							
3	13.1							
4	13.1							
5	13.1							
6	13.1							
7	13.1							
8	13.1							
9	13.1							
10	13.1							
11	13.1							
12	13.0							

APC #6 E53914

MAINTENANCE REPORT

Site	Date	Report Number
San Juan / Mayaguez, PR	10/25/00	

Type of Maintenance: ☐ Scheduled ☑ Unscheduled ☐ Emergency repair

Event description: evaluation & site visit for DOE

Action Taken: ☐ Adjustment ☐ Test ☐ Repair ☐ Replacement ☒ Inspection

Notes:

Battery 13.8
PV 14.3
Inverter 120

Subsystems involved:

☐ Array ☐ Battery
☐ Controls/switches ☐ Generator
☐ Other: ☒ Structure Floor rotten wood & floor braket broke loose

Problem Occurred: ~~None~~
Date: _____
Time: _____

Action completed
Date: None
Time: _____

System Off-Line?
☐ Yes ☐ No
Downtime hours: ___

Parts Replaced:

Labor: Repair hours: _____ Crew Size: ___ Man-hours: _____

Status: Work Complete? ☐ Yes ☐ No

Notes:

Report Completed by: B Young

SunWize Technologies, Inc.

#4 E53913 MAINTENANCE REPORT

Site	Date	Report Number
San Juan Mausoleo - PR	10/28/00	

Type of Maintenance: ☐ Scheduled ☒ Unscheduled ☐ Emergency repair

Event description:

Action Taken: ☐ Adjustment ☐ Test ☐ Repair ☐ Replacement ☒ Inspection

Notes:
Battery 26.5
PV 25.18
Inverter 120

Subsystems involved:
☐ Array ☒ Battery loose battery cables
☐ Controls/switches ☐ Generator
☐ Other: ☒ Structure rust on Cabinets

Problem Occurred: Painted rust
Date: _____
Time: 30 min

Action completed on Cabinet
Date: _____
Time: _____

System Off-Line? ☐ Yes ☐ No
Downtime hours: ___

Parts Replaced:

Labor: Repair hours: 30 min Crew Size: 2 Man-hours: ___

Status: Work Complete? ☐ Yes ☒ No

Notes:

Report Completed by: B Young

BATTERY LOG SHEET
Sealed Lead-Acid Batteries

Cell no. 1 is the cell that is connected to the main battery negative lead (black).

Date								

Cell #	V	V	V	V	V	V	V	V
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

SunWize Technologies, Inc. ES3912 Trailer #1

MAINTENANCE REPORT

Site		Date	Report Number
Emm	Md	4-9-01	

Type of Maintenance: ☒ Scheduled ☒ Unscheduled ☐ Emergency repair

Event description: evaluation & site visit for DOE

Action Taken: ☐ Adjustment ☐ Test ☐ Repair ☐ Replacement ☒ Inspection

Notes:

Subsystems involved: ☒ Array ☐ Battery

10 of ☐ Controls/switches ☐ Generator

☐ Other: ☐ Structure

Problem Occurred: PV combiner wire loose

Date: 4-9-01 Time: 1 pm

Action completed

Date: _____ Time: _____

System Off-Line? ☐ Yes ☐ No

Downtime hours: ___

Parts Replaced: N A

Labor: Repair hours: _____ Crew Size: ___ Man-hours: _____

Status: Work Complete? ☐ Yes ☐ No

Notes:

Report Completed by:

SunWize Technologies, Inc. E#3912

BATTERY LOG SHEET
Sealed Lead-Acid Batteries

Cell no. 1 is the cell that is connected to the main battery negative lead (black).

Date								

Cell #	V	V	V	V	V	V	V	V
1	13.6							
2	13.2							
3	13.2							
4	13.1							
5	13.1							
6	13.1							
7	13.1							
8	13.1							
9	13.1							
10	13.1							
11	13.1							
12	13.2							

Site Evaluation Form

DOE-Evaluate Deployment of Photovoltaic Systems for Disasters
Florida Solar Energy Center
10-20-2000

1. Date of visit: April 30 → May 1, 2001

2. Site Location: Denton, TX FEMA-Region VI

Address: FRC 800 North Loop 288
Denton, TX 76209

3. Contacts: John Hyatt
Ed Hartis
Phone: 940-898-5223, F5512
940-898-5101

4. Trailer Identification:
1 Sunwise E53910 #2 2. APC #7 E53915

5. Trailer Status:
Being used:
1. NO 2. NO
Present Working Status
1. All switches ON & operational 2. All switches were on & System was Op
Maintenance Done:
1. titen bolts on wires, batteries & PV 2. painted rust
Broken Parts:
1. cover/door on AC outlet box Combiner box 2. Botton brace broke from frame on right front Trailer

6. Trailers Repairs:
Past Repairs:
1. NONE 2. none
Present Repairs:
1. NONE 2. NONE

7. Viability:
Trailer 1. Too small for their operations (not used) need 25KW & larger
2. " to power coordination & operation centers

9. Evaluation Completed By: B Young

E53910 #2 **MAINTENANCE REPORT** Sunwise

Site	Date	Report Number
Denton, TX	4-30-2001	

Type of Maintenance: ☒ Scheduled ☒ Unscheduled ☐ Emergency repair

Event description:
Visit

Action Taken: ☒ Adjustment ☐ Test ☐ Repair ☐ Replacement ☒ Inspection

Notes: System on & operational

Subsystems involved: ☐ Array ☐ Battery ☑ Controls/switches ☐ Generator ☐ Other: ☐ Structure

Loose bolt on Battery

AC outlet box broke

Problem Occurred: Date: _____ Time: _____

Action completed: Date: _____ Time: _____

System Off-Line? ☐ Yes ☐ No

Downtime hours: ___

Parts Replaced: none

Labor: Repair hours: 0 Crew Size: ___ Man-hours: ___

Status: Work Complete? ☐ Yes ☒ No

Notes: _____

Report Completed by: BJ

BATTERY LOG SHEET
Sealed Lead-Acid Batteries

E53910 #2

Cell no. 1 is the cell that is connected to the main battery negative lead (black).

Date	4-30-01						

Cell #	V	V	V	V	V	V	V	V
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

+ 13.3 17.5

12.4 11.85 14.3 12.5

Bad

13.4 13.4 13.0 13.7 (-)

loose

APC E53915 **MAINTENANCE REPORT** #7

Site	Date	Report Number
Denton Tx	4-30-2001	

Type of Maintenance: ☐ Scheduled ☒ Unscheduled ☐ Emergency repair

Event description: System ON & operational

Action Taken: ☐ Adjustment ☐ Test ☐ Repair ☐ Replacement ☒ Inspection

Notes: NONE

Subsystems involved: ☐ Array ☐ Battery ☐ Controls/switches ☐ Generator ☐ Other: ☐ Structure

Problem Occurred: Date: _____ Time: _____

Action completed Date: _____ Time: _____

System Off-Line? ☐ Yes ☐ No

Downtime hours: ____

Parts Replaced: NONE

Labor: Repair hours: 0 Crew Size: ____ Man-hours: ____

Status: Work Complete? ☐ Yes ☐ No

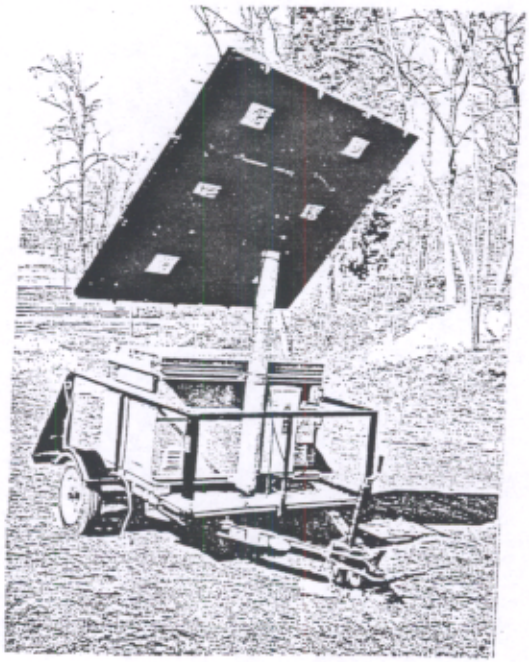
Notes: _____

Report Completed by: BY

APPENDIX B

DOE/FEMA O&M Manual

DOE
FEMA
O&M MANUAL



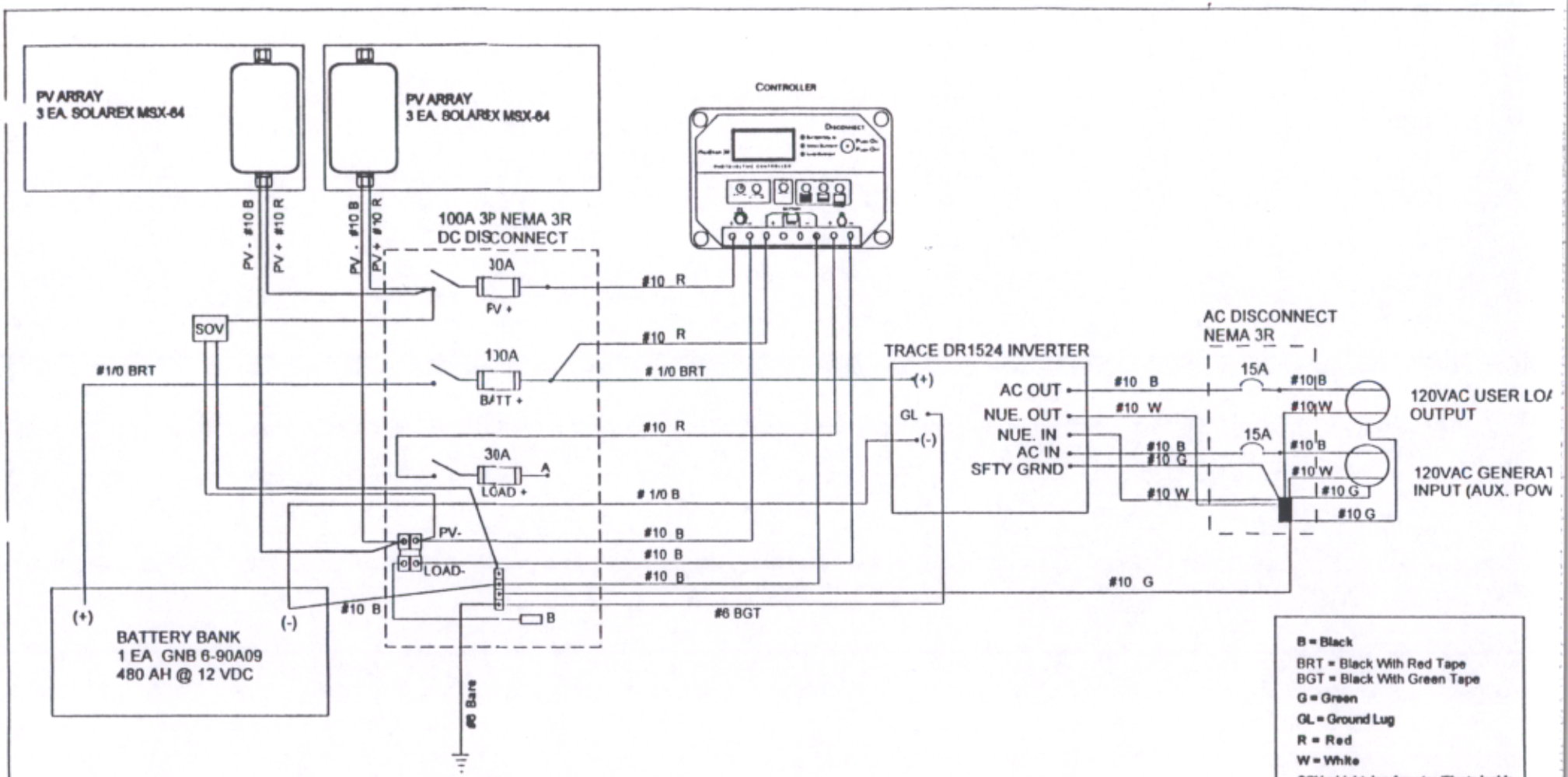
PPS-500-TRAILER MOUNTED PHOTOVOLTAIC SYSTEM

APPLIED POWER CORPORATION
1210 HOMANN DR. SE
LACEY, WA 98503
(360) 438-2110
FAX: (360) 438-2115

4. PARTS LIST

ITEM	QTY	SUGGESTED SPARES QTY	MODEL	MFG.	DESCRIPTION
PV Array					
	6	0	MSX-64	Solarex	PV Module
	1	0	FRPTO6/SX	Zomeworks	Array Support Structure
	4	0	MSX-INT/P	Applied Power	Module Interconnect
	2	0	MSX-Out 10	Applied Power	Module Output Cable
Battery	1		6-90A09	GNB	Sealed AGM Battery
Inverter					
	1	0	DR1512	Trace Engineering	1500 Watt Inverter - 120 VAC Output
	1	0	Trace BTS	Trace Engineering	Battery Charging Temp. Sensor
Charge Controller	1	0	Prostar 30 CLCD	Morning Star	30 Amp Controller
Enclosure					
	1	0	PPS-500	Applied Power	30" X 48" x 30" Steel Enclosure
	1	0	PPS-500 POLE 4"	Applied Power	Array Support Pole and Clamps
	2	0	T-11-2	T&B	Single Gang Weatherproof Box
	1	0	Hubbell 4716 -C	Hubbell	AC Input Flanged Inlet
	1	0	Hubbell 4729-C	Hubbell	AC Input Cord Cap
	1	0	WP-1	Hubbell	Weatherproof Cover for Flanged Inlet
	1	0	5262-I	Leviton	Duplex Receptacle
	1	1	E9UVC	Carlon	Weatherproof Duplex Receptacle Cover
	4	0	A-VK44	Hoffman	Louver Cover
	4	0	A-FLT44	Hoffman	Louver Filter
	1	0	PPS-500-Wire	Applied Power	AC and DC Wiring
	1	0	PPS-500- Label	Applied Power	Custom Label Set
AC Disconn. Switch					
	1	0	QO2-4L70RB	Square D	2 Position Load Center
	2	0	QO115	Square D	15 Amp Circuit Breaker
DC Disconn. Switch	1	0	TG4323R	General Electric	Safety Switch
	2	1	FLNR 30	Little Fuse	30 A Fuse
	1	1	FLNR 100	Little Fuse	100 A Fuse

Lightning Arrestor	1	1	PLA 100V	Pulse	12 VDC lightning Protection
Trailer	1	0	4x6x2 Utility	TowNGo	Transport Trailer
Manual	1	0	PPS-500-Manual	Applied Power	Operation and Maintenance Manual



NOTE: If User has DC load, positive lead should be attached to fuse end of fused disconnect in DC Disconnect Box (Point A) and negative lead should be attached to Splicer/Reducer Sleeve floating in DC Disconnect Box (Point B).

B = Black
BRT = Black With Red Tape
BGT = Black With Green Tape
G = Green
GL = Ground Lug
R = Red
W = White
SOV = Lightning Arrestor (Floats Inside Disconnect Box)
= Terminal Block Floating in DC Disconnect Box
= Negative (-) Buss in DC Disconnect Box
= Negative (-) Buss in AC Disconnect Box

Applied Power Corporation
1210 Hamann Dr. SE

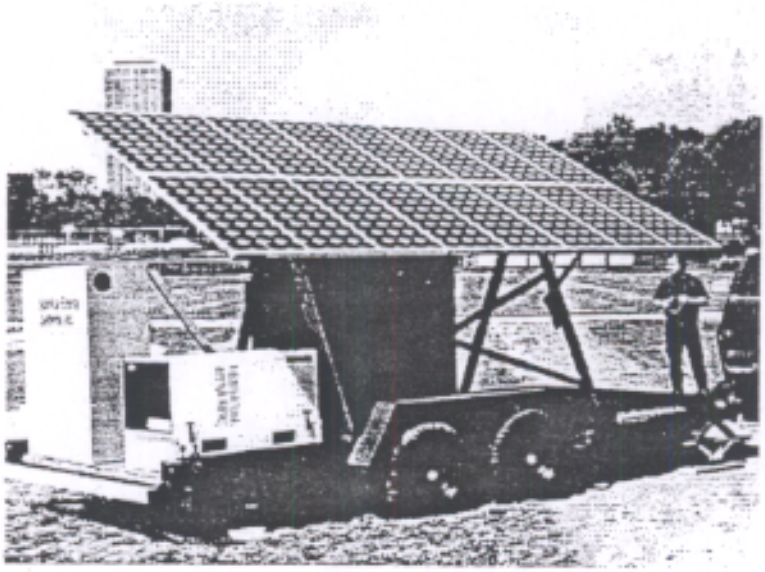
TOLERANCES
UNLESS SPECIFIED

DO NOT SCALE DRAWING
DIMENSIONS (Inches/Feet)
TEAM
DESIGN

PPS-500
ELECTRICAL SCHEMAT

SunWize
TECHNOLOGIES, INC.
A Besicorp Company

PV
Power Station
Highway Trailer



Operation & Maintenance Manual

PM403003 Rev. B

Corporate Headquarters
90 Boices Lane • Kingston, NY 12401 • (914) 336-0146 • Fax (914) 336-0457
e-mail: sunwize@besicorp.com • www.sunwize.com

SunWize Technologies, Inc.

6. POWER STATION COMPONENT LIST SN: **1012** Date: 08-24-98

Location: Bluemont, VA Application: Disaster Relief

Owner: Federal Emergency Management Agency Phone: (540) 542-2072

Address: 19844 Blueridge Mt. Rd., Bluemont, VA 20135 Fax: _____

Contact: Ray Berry Ship date: 08-31-98

Array Size:
- [ ] 600
- [ ] 900
- [ ] 1200
- [ ] 1500
- [x] 1800
- [ ] 2400
- [ ] _____

Structure:
- [x] Road trailer
- [ ] Off-road trailer
- [ ] Ground
- [ ] Breakdown
- [x] Painted
- [ ] Galvanized
- [x] Hinged array

Inverter:
- [X] 4.0 kVA, 24 VDC: 120 VAC, 60 Hz, 1 phase, 2-wire
- [ ] 3.0 kVA, 24 VDC: 230 VAC, 50 Hz, 1 phase, 2-wire
- [ ] 4.0 kVA, 24 VDC: 220 VAC, 60 Hz, 1 phase, 2-wire
- [ ] 5.5 kVA, 48 VDC: 120 VAC, 60 Hz, 1 phase, 2-wire
- [ ] 4.5 kVA, 48 VDC: 230 VAC, 50 Hz, 1 phase, 2-wire
- [ ] 8.0 kVA, 24 VDC: 120/240 VAC, 60 Hz, 1 phase, 3-wire
- [ ] _____

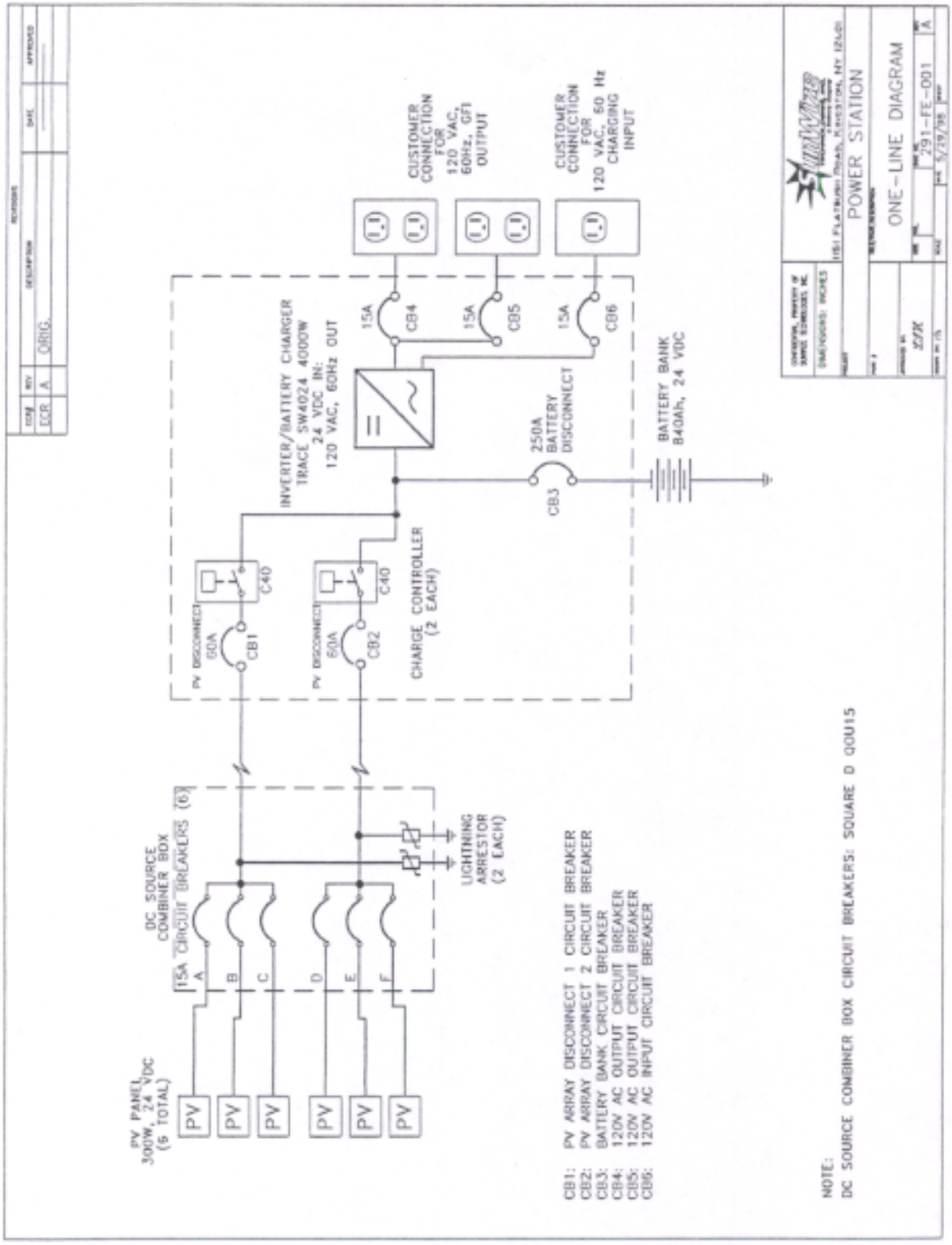
Generator:
- [ ] 6 kVA LP fuel
- [ ] 10 kVA LP fuel
- [ ] 7.5 kVA diesel fuel
- [X] N/A

Battery:
- [ ] Industrial lead-acid, flooded 2V cells, 1000 Ah
- [ ] Economy lead-acid, flooded, 6V cells, 700 Ah
- [X] Valve-regulated lead-acid, sealed 12V cells, 1050 Ahr
- [ ] _____

Monitoring:
- [X] Local
- [ ] Remote/control panel, 50 ft. [15 m] cable
- [ ] Remote/control adapter and PC hardware
- [X] Trace C40DVM and SW4024 LCD displays

Other/notes:

2 - Trace C40 DVM PWM PV charge controllers
1 - Trace DC250 Disconnect with 1 - 250A battery disconnect circuit breaker and
2 - 60A PV disconnect circuit breakers
2 - 15A 120 VAC load circuit breaker
2 - duplex GFCI receptacle with weatherproof cover
1 - 15A 120 VAC charging input circuit breaker, connector receptacle and plug with cord
Battery box padlock combination: **1998** Enclosure Key Code: **C415A**


POWER STATION
ONE-LINE DIAGRAM
291-FE-001
5/29/98
PV PANEL 300W, 24 VDC (6 TOTAL)
DC SOURCE COMBINER BOX
15A CIRCUIT BREAKERS (6)
LIGHTNING ARRESTOR (2 EACH)
PV DISCONNECT 60A
CB1
CB2
C40
CHARGE CONTROLLER (2 EACH)
INVERTER/BATTERY CHARGER TRACE SW4024 4000W 24 VDC IN: 120 VAC, 60Hz OUT
15A
CB4
CB5
CB6
CUSTOMER CONNECTION FOR 120 VAC, 60Hz, GFI OUTPUT
CUSTOMER CONNECTION FOR 120 VAC, 60 Hz CHARGING INPUT
250A BATTERY DISCONNECT
CB3
BATTERY BANK 840Ah, 24 VDC
CB1: PV ARRAY DISCONNECT 1 CIRCUIT BREAKER
CB2: PV ARRAY DISCONNECT 2 CIRCUIT BREAKER
CB3: BATTERY BANK CIRCUIT BREAKER
CB4: 120V AC OUTPUT CIRCUIT BREAKER
CB5: 120V AC OUTPUT CIRCUIT BREAKER
CB6: 120V AC INPUT CIRCUIT BREAKER
NOTE:
DC SOURCE COMBINER BOX CIRCUIT BREAKERS: SQUARE D QOU15

APPENDIX D

Performance Data

Photovoltaic Applications

for Disaster Relief

Hurricane Andrew struck the coast of South Florida on August 24, 1992. The storm was a level four hurricane with sustained winds of 140 mph. Waves reaching 18 feet pounded the shoreline flooding buildings and washing boats on shore. At least 85,000 buildings were severely damaged and an estimated 34,000 homes

APPENDIX D

Performance Data

SUNWISE GENERATOR
MDL #

Emmitsburg, Md

Solar Generator Data Dec 98

Date: 12/10/98
Time: 08:10

	Array #1	Array #2	
Reset Amp Hours:	4.7/271.5	4.3/41.8	Weather Conditions:
Current Load:	1A	1A	
Battery Temp. Comp.:	24.4	24.4	Comments:
Inverter Volts (AC):	123	123	
Watts:			
Temperture:	30 deg.	30 deg	
Battery Voltage:	24.9	24.9	

Date: 12/11/98
Time: 07:53

	Array #1	Array #2	
Reset Amp Hours:	0	0	Weather Conditions:
Current Load:	2A	2A	
Battery Temp. Comp.:	23.5	23.5	Comments:
Inverter Volts (AC):	122	122	
Watts:			
Temperture:	42 deg.	42 deg.	
Battery Voltage:	24.2	24.2	

Date: 12/14/98
Time: 08:19

	Array #1	Array #2	
Reset Amp Hours:	264.7	264.6	Weather Conditions:
Current Load:	2A	2A	
Battery Temp. Comp.:	23.8	23.8	Comments:
Inverter Volts (AC):	121	121	
Watts:	194	194	
Temperture:	39 deg.	39 deg.	
Battery Voltage:	24.2	24.2	

Date: 12/15/98
Time: 08:02

	Array #1	Array #2	
Reset Amp Hours:	411.6	408.6	Weather Conditions:
Current Load:	2A	2A	
Battery Temp. Comp.:	25		Comments: * - *not inverting, (light out)*
Inverter Volts (AC):	118	*	
Watts:	38	38	
Temperture:	22 deg.	22 deg.	
Battery Voltage:	25.4	24.4	

Date: 12/16/98
Time: 08:05

	Array #1	Array #2	
Reset Amp Hours:	553.1	549	Weather Conditions: *Overcast all day (heavy)*
Current Load:	0.02	0.02	
Battery Temp. Comp.:	23.7	23.7	Comments: *Load on battery power*
Inverter Volts (AC):	122	122	
Watts:	0	0	
Temperture:	34 deg.	34 deg.	
Battery Voltage:	24.2	24.2	