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Publication Number

FSEC-PF-284-94

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REAL LIFE APPLICATIONS OF PHOTOVOLTAIC POWER TO HURRICANE ANDREW RELIEF

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INTRODUCTION

On August 24, 1992, Hurricane Andrew struck the coast of South Florida and devastated Dade County leaving several hundred-thousand people homeless. Over a million residences were without electrical service, functional water and sewage systems and medical services for days and weeks in the aftermath of the storm. Emergency management teams, medical personnel, the military and countless public and private organizations staged a massive relief effort.

The staff at the Florida Solar Energy Center and SANDIA National Laboratory responded to the disaster with solar electric powered equipment to assist in the relief effort. Electricity generated by solar (photovoltaic) cells were used to power vaccine refrigerators, microscopes, lighting, radios, and other general electrical needs at temporary medical shelters and emergency communication stations. Photovoltaic (PV) power systems generated quiet, pollution-free electrical power.

WHAT IS PHOTOVOLTAIC POWER

Photovoltaics is the process by which light is converted directly into electricity. When a photon of light strikes an atom of silicon in a solar cell, the transfer of energy frees an electron. This freed electron produces an electric current in a circuit. This process generates free electrons at an efficiency from 3 to 29 percent, based on the composition and design of the cell.

A voltage potential is created between the positive and negative sides of the photovoltaic cell as shown in Figure 1. Each cell produces about 0.5 volts depending on its composition. The cell acts as a current generator, as more light strikes the cell more current is generated. The amount of current generated depended mostly on the amount of surface area exposed to light.

Modules are produced by connecting PV cells in series and parallel combinations to generate a desired voltage and current. A typical commercial module generate 12 volts at 3 amperes of direct current, with other standard module outputs available. Standard commercial modules operate at efficiency from 4 to 14 percent.

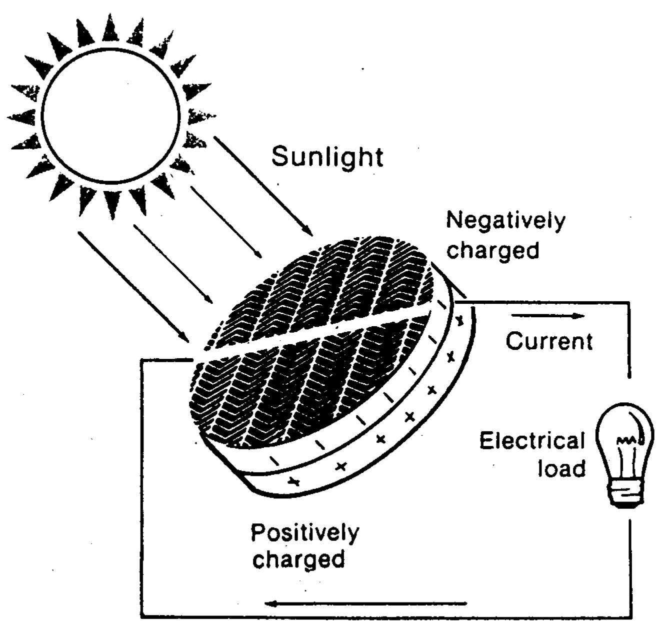

Figure 1. Photovoltaic cell.

A PV cell is an energy conversion device, therefore the amount of energy converted depends on the amount it receives and its efficiency in converting the energy. There are 1358 watts per square meter of energy in sunlight above the earth's atmosphere. At sea level, the amount of energy in sunlight is reduced to 930 watts, due to atmosphere attenuation. The amount of energy at the earth's surface varies greatly with the position of the sun, cloud cover, air pollution, and other factors. An excepted standard defines One Full Sun at the earths surface as 1000 watts per square meter. This Full Sun value is only available a few hours per day as the earth rotation and atmospheric conditions determines its value. On the average, 1000 watts of energy is available 3 to 4 hours per day based on you location and related factors.

PV DESIGN CONSIDERATIONS

PV cells by themselves are limited in use. In a system, they are capable of powering a variety of electrical and electronic equipment. One of the most widely used system designs is stand-alone, where utility power is not available. Energy from the sun, as a single source, is converted directly to electrical energy to power one or more loads as a stand-alone system. There are other system designs using PV power, such as utility interactive.

A stand-alone PV system typically consist of a PV array, system controller, battery pack and load. The PV array supplies power to a battery pack that generally powers the load directly. The system controller controls the energy flow between the array, batteries, and loads to insure safe and reliable operation.

HURRICANE DAMAGE

Hurricane Andrew struck the coast of South Florida at Homestead on Monday, August 24th, 1992. About 750,000 people were evacuated from the area in the 19 hours before the storms arrival. The storm cut a 25-mile path of destruction across Dade County with winds gusting to 170 miles per hour.

At least 85,000 buildings were severely damaged and an estimated 34,000 homes will have to be replaced. Over two hundred-thousand people were left homeless and 51 deaths were attributed to the storm. Storm damaged residences were without electrical service, functional water and sewage systems for days and weeks in the aftermath of the storm. Figure 2 shows the extent of some of the damage.

Clinics, hospitals, fire stations and police stations were also left without services or damaged beyond use. Emergency management teams, medical personnel, the military and countless public and private organizations staged a massive relief effort. Life supporting resources were in immediately need, such as food, water, and medical supplies.

Figure 2. Illustration of Damage.

Supplies of food, water and medical needs poured into the disaster area to relieve human emergency needs, but the destruction was so overwhelming that it would by months before the area would be restored as it was before the storm, if ever. Medical, fire and police services will be needed during the weeks of reconstruction. It will be a difficult task to rebuild businesses and homes without the usual services of water, sewer, and electricity. Make shift shelters and temporary medical clinics were made out of buildings that received little damage and were safe to occupy.

ASSISTANCE NEEDED

Communication was very important to emergency personnel to request assistance, supplies, and information. In response to a request for assistance from the Miami Emergency Management Office, a portable photovoltaic power system was transported to Miami by the Florida Solar Energy Center to assist with powering emergency communication equipment until utility power could be restored.

The University of Miami, Field Epidemiology Survey Team (FEST) asked the Florida Solar Energy Center (FSEC) if they could supply any photovoltaic systems to provide power at temporary medical clinics. FSEC was not prepared to supply extensive portable PV power system, as the photovoltaic equipment at the Center was used in experiments and under test for manufacturers. FSEC asked SANDIA National Laboratory for assistance with obtaining needed components to complete five portable stand-alone units. The systems will be on loan to the University of Miami until utility power is restored. Uncommitted equipment and newly obtained components were assembled into the needed photovoltaic power systems in a short period of time and delivered to the Dada county area.

The temporary medical clinics will be maned 24 hours per day. Medical services will need to be provided to people injured in the storm, also, during clean-up and rebuilding. The control of disease will be important as the medical teams survey the health conditions of the people still living and working in the disaster area. Simple laboratory work will need to be carried out at the clinics, due to the difficulty in transportation people and materials.

FEST determined that they needed both DC and AC power as listed in Table 1.

- Refrigerators for cooling medicine
- Lights for working and security
  - Laboratory Equipment (Sterilizer, microscope)
- Radios for Communication
- Fans for cooling

Table 1. List of Needs.

Three 12 volt DC vaccine refrigeration units were install at three of the sites. The units were previously obtained for testing for the World Health Organization. Ice packs were provided in the freezer compartments to sustain cooling temperatures as medicines are removed. Opening the refrigerators was held to a minimum. General foods and beverages were not to be stored in the refrigerators to minimize the load. It was determined that small size refrigerators helped to minimize unnecessary use.

DESIGN OF THE PV POWERED SYSTEMS

The five system were designed to be identical for ease of maintenance, trouble shooting and training. A modular design was used for ease of transportation and assembly. The design divided the system into three assemblies; photovoltaic array, battery box, and controller/distribution unit.

To meet the needs of the medical clinics, each system was configured to contains the components in the diagram as shown in Figure 3.

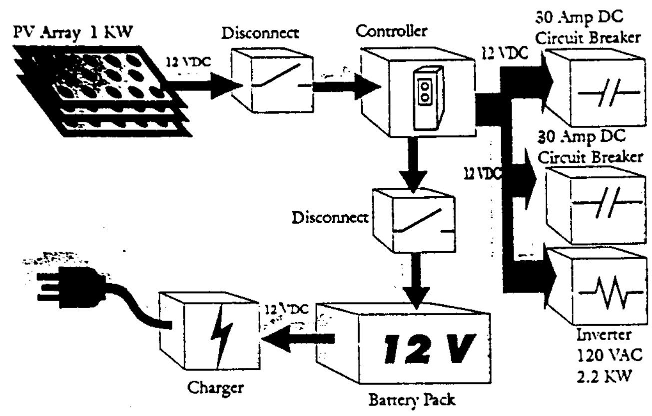

Figure 3. PV System Diagram.

Two 12 VDC load distribution outlets were provided to power portable equipment such as the refrigerators, radios, lights, fans and other portable medical equipment. A 120 VAC inverter rated at 2,200 watts was provided to power portable X-ray equipment, other major medical equipment requiring 120 VAC, including lights and fans. All loads must be used with energy conservation in mind as the PV systems maximum energy output is 4,000 watts-hours on a clear sunny day.

The battery bank consisted of ten flooded lead-acid deep-cycle batteries rated at 6 volts and 350 amphours. The batteries were configured to provide 1750 amphours at 12 VDC. The two 12 VDC circuits would feed directly from the battery bank through a low voltage disconnect to protect the batteries from over-discharge. The inverter was directly connected to the battery through a 200 amp quick disconnect. During inclement weather or excessive usage a 50 amp charger was provided to charge the battery bank form a 120 VDC generator.

The system controller was designed to protect the batteries form over-charge and over-discharge. A voltage sensing device controls relays to regulate the charge and discharge of the batteries. The controller was set to 14.6 volts for over-charge disconnect and 13.5 volts for reconnecting the PV array for charging. Low voltage disconnect had two setpoints for DC loads: 11.75 volts for non-critical loads, 11.25 volts for critical loads. All loads were reconnected at 12.5 volts. The inverter was pre-set to disconnect with its own load disconnect at a battery voltage of 11 volts.

The system was negatively grounded through the array, battery and inverter to earth ground. Fused disconnect switches were provided at the PV array and battery for safety and code requirements.

USE OF THE SYSTEMS

The PV systems were constructed at FSEC on September 6 and transported to Miami for installation. Four of the five systems were install at location listed in Table 2.

- St. Annes Catholic Mission
- Project First Base
- South Dade Migrant Labor Camp
- Emergency Management Relief Center

Table 2. PV System Installations

The PV systems were on site for various lengths of time. As rebuilding took place and utility power was restored the PV system were disassembled and returned to FSEC. The last system was returned after being on site 4 months.

The systems operated as designed, but need to be more user friendly. The users had so experience with PV that they felt the system were to complicated. The system were not designed for user friendliness, but to be designed and constructed in three days and to work, which they did as shown in Figure 4.

Also, there were five photovoltaic powered street lights install at each location for area security. The street lights provided light throughout the night allowing people to find and enter the centers safely.

CONCLUSION

Photovoltaic power system are a viable source of electrical power. There are various design configurations including portable, stand-alone, utility interactive and others. PV systems are capable of being design to meet various requirements of portability, stand-alone operation, various loads, and operating times. The quiet, pollution-free electrical power generated by photovoltaic power systems is very beneficial. Fuel is not needed, as the sun is an endless supply of energy. The two applications presented in this paper for use with medical clinics and communications stations proves the usefulness of PV power systems for future disaster relief efforts.

Figure 4. PV System at a clinic.

REFERENCES

Coletti, R. J., "Swift Recovery, Stronger Economy," Florida Trend, V. 35, No. 6, October 1992, pp. 32.

Conners, Sharon, "Andrew Trashes South Florida Leaving Contractors to Clean up the Roofs," RSI, V. 69, No. 10, October 1992, pp. 24-26+.

Melody, I., "Sunlight After the Storm," Solar Today, American Solar Energy Association, Denver, CO, November, 1992.

Photovoltaic-Powered Medical Relief Shelters for Hurricane Andrew Disaster Assistance, Operation and Maintenance Manual, FSEC-CR-531-92, Florida Solar Energy Center, Cape Canaveral, FL, 1992.

Reason, J., "Florida P&L vs. Hurricane Andrew," Electrical World, V. 206, No. 10, October 1992, pp. 33+.

Setzer, Steven W., "Andrew Aftermath Assessed," ENR News, V. 229, No. 17, October 26, 1992, pp. 7.

When Disaster Strikes, the Sun Can Still Shine Through, Tomorrow's Energy Today for Cities and Counties, National Renewable Energy Laboratory, Golden, Co. 1994.

Young, Jr., William R., *Hurricane Andrew Photovoltaic Traffic Control Relief*, FSEC-CR-550-92, Florida Solar Energy Center, Cape Canaveral, Florida, 1992.