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Author

Young, William R.

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Presented by:
William R. Young, Jr.
Florida Solar Energy Center
1679 Clearlake Road
Cocoa, FL 32922-5703

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William Young, Jr.
Florida Solar Energy Center
1679 Clearlake Road
Cocoa, Florida 32922

ABSTRACT

Man made or natural, disasters can happen at any time, often with little or no advance warning. Major disasters, such as hurricanes, floods, tornados, and earthquakes, can leave many people without adequate medical services, potable water, electrical service and communications. They can be as destructive as Hurricane Mitch leaving several hundred-thousand people homeless or as minor as an afternoon thunderstorm knocking down local power lines to your home.

In response to a disaster, photovoltaic (solar electric) modules offer a source of quiet, safe, pollution-free electrical power. Photovoltaic (PV) power systems are capable of providing the electrical needs for vaccine refrigerators, microscopes, medical equipment, lighting, radios, fans, communications, traffic devices and other general electrical needs. Stand-alone PV systems do not require refueling and operate for long periods of time from the endless energy supplied by the sun, making them beneficial during response and recovery efforts.
This report discusses the need for electrical power during a disaster, and the capability of PV to fill that need. Applications of PV power used during previous disaster relief efforts are also presented.

1. INTRODUCTION

In October 1998, Hurricane Mitch struck the coast of Honduras with a tremendous destructive force. With winds of over 100 miles per hour, Mitch displaced over 1 million people and destroyed over 100,000 homes. Thousands of businesses and homes that were still standing were without electrical service, functioning water and sewage systems, communications, and medical services for days, even weeks and months in the aftermath of the storm. Shelters, medical clinics, hospitals, fire stations, and police stations also suffered damages and loss of utility services.

Natural disasters, such as hurricanes, floods, tornadoes, and earthquakes often occur with little advance notice, disrupting the normal daily community routine. Emergency management teams, the military, and countless public and private organizations respond to such disasters with massive relief and rebuilding efforts. Food, water and medical supplies for life support are provided to survivors in the disaster area. Generators of all sized and types are provided for electrical power during the recover effort.

Many of the energy requirements of emergency management organizations, relief workers, and the general public can be satisfied with photovoltaic power systems. This inexhaustible source of clean and quiet energy from the sun can be quickly applied to power a variety of equipment.

Fig. 1 Home Destroyed in Florida City from Andrew.

2. EMERGENCY MANAGEMENT

The organized comprehensive handling of disasters and hazards and their consequences was institutionalized in the United States in 1979 with the creation of the Federal Emergency Management Agency. All levels of government (federal, state, county, and local) and the private sector (business and industry, voluntary organizations, and the general public) contribute toward a close working partnership to manage disasters. Local governments manage all types of hazards and disasters, with responsibility for making plans and providing the primary resources for public protection. Local governments provide and maintain police and fire protection, highway resources, municipal facilities, equipment, supplies, and personnel capabilities to resolve prevailing problems. In the event local government does not have sufficient resources to meet demands, assistance is requested from the State or Federal Government.

Emergency management personnel from public agencies, organizations and utilities are organized into teams for resolution of emergency situations within a disaster or incident and also provide resources for recovery. The teams are organized into service areas called Emergency Support Functions (ESF) follows:

Transportation	Communication
Public Works & Engineering	Fire Fighting
Information & Planning	Mass Care
Resource Support	Health & Medical Service
Search & Rescue	Hazardous Materials
Food & Water	Energy
Military Support	Public Information
Volunteers & Donations	Law Enforcement
Animal Issues	

3. PV USAGE DURING DISASTERS

Since Hurricane Hugo, there had been limited use of photovoltaics in a disaster where it had been first introduced to emergency management organizations by members of the PV industry. Different PV-powered applications have been demonstrated in the various Emergency Support Functions. In recent years, however, photovoltaics have supplied emergency power for Hurricanes Hugo, Andrew, and Luis, along with the Northridge Earthquake in Southern California, USA.

In 1989, Hurricane Hugo cut across the island of St. Croix in the Virgin Islands, disrupting power all over the island. At the time, 12 Volt Catalog (PV distributer) assembled thirty small portable PV systems using Sovonics Solar System or ARCO Solar PV modules by connecting either one of them to a deep cycle Interstate Battery. The units were used at various disaster shelters, medical facilities, and emergency management offices to power 12 VDC florescent lights, fans and Ham Radios. These companies have since become Geosolar, United Solar Systems and Siemens Solar.

When Hurricane Hugo later struck the State of South Carolina USA, a trailer mounted, PV-powered generator was transported to the devastated area to assist with relief efforts. This Solar Emergency Response Vehicle powered a law enforcement traffic facility and an orphanage until utility power was restored. The unit built by Arizona Solar Energy Office and Photocomm supplied 12 VDC, 115 and 220 VAC of electrical power which operated 24 hours per day from a 2,640 peak watt PV array.

In the summer of 1991, Barrett Manufacture built an Emergency Mobile Communications and Lighting system for earthquake recovery efforts at Northridge in Los Angeles, California, USA. The trailer mounted, PV-powered generator provided reliable standalone electrical power at both 12 VDC and 120 VAC. The unit contained 4 Siemens 48 watt PV modules.

In 1992, The Miami Emergency Management Office sent out requests for emergency communications assistance after Hurricane Andrew stuck Miami, Florida, USA. The staff at the Florida Solar Energy Center (FSEC) transported to Miami a portable photovoltaic power system to power an amateur radio station. The system assisted with emergency communication until permanent resources were restored. A PV workshop training unit was used because of its capability to operate as a portable standalone PV system and was of sufficient size to be able to power a 30-watt ham radio for 24-hour operation.

FSEC together with SANDIA National Laboratory responded to a request from the University of Miami, Field Epidemiology Survey Team (FEST) for PV systems to power temporary medical clinics. In response to the request, five photovoltaic power systems were assembled in a short period of time and then delivered to the disaster area in Dade County. Each system consisted of a 1-kWp PV array, battery bank, controller and a 2 kWh DC/AC inverter.

These FEST PV systems provided power at the temporary medical clinics for 24-hour-per-day operation. Medical services were desperately needed for people injured not only in the storm, but also during the cleanup and rebuilding. Lights, radios, fans and medical laboratory equipment were powered by the PV systems installed throughout Miami. Some old 12-volt DC vaccine refrigeration units were installed at three of the sites. The units were previously obtained for World Health Organization testing for developing countries.

Long before Hurricane Andrew struck South Florida, USA, PV-powered streetlights had been installed in a Miami suburb. After the storm, all 33 streetlights were still standing and provided the only light in the area until utility power was restored. The streetlights consisted of a pole-mounted fixture that contained a battery and controller enclosure, two PV modules and a flourescent lamp. The streetlights were manufactured locally by Solar Outdoor Lighting, who later provided additional units installed at security stations, temporary medical clinics, and shelters in the disaster area.

The Florida Department of Transportation was already equipped with numerous PV power traffic devices used for road construction. When Andrew struck, a PV-powered highway advisory radio unit built by Digital Recorders was operating along I-75 in the Everglades transmitting messages about rest stops and tolls. After the storm, the AM radio transmitted road hazards and route changes in the disaster area. Additional trailer mounted units were installed along the Florida Turnpike to provide further information as shown in Figure 2.

Fig. 2 PV powered radio transmitter along I-75.

Other PV-powered traffic devices were transported to the disaster area to assist in the relief effort. Traffic control was increased by use of changeable highway message signs, flashing arrow boards, and warning signals and signs.

The destruction from Andrew was so overwhelming that it affected people in all walks of life. Many families did not have the capability to relocate and leave behind what little they owned. Since it took weeks for utility power to return to some of them staying, flashlights became prize possession and batteries were in great demand. Kyocera

America responded by providing several hundred solar lanterns. The lanterns have a 6-watt fluorescent bulb powered by a 5-watt PV module and a battery for up to five hours of operation as shown in Figure 3.

Fig. 3 PV Powered Lantern Used in Miami.

After Hurricane Luis, Miox Corporation provided PV-powered water purification units to the Virgin Islands. The units produce hundreds of gallons of potable water per day.

4. APPLICABLE USES

The loss of electrical power after a disaster quickly makes us realize how dependent our society is on electricity. Medical, fire and police services are needed immediately after a disaster and during the period of reconstruction. Communication was very important to emergency personnel to request assistance, supplies, and information. It would be a difficult task to rebuild businesses and homes without the usual services of water, sewer, and electricity. Emergency

Management Teams, the military, and countless public and private organizations providing recovery efforts require varying amounts of electrical power.

The Emergency Support Functions performed by the many emergency management organizations cover a wide spectrum of relief and recovery efforts. Many of the resources needed to perform these support functions require standalone electrical power. Fast and deliberate deployment of equipment is needed in response to a disaster; therefore, ready-to-use systems designed for individual applications are most effective. These resources can be specified as individual equipment related to a function or application and are defined as follows:

- Building or backup power
- Call boxes
- Flashing arrow boards
- Flashing warning signals and signs
- Folding man packs
- Hand-held radio transceivers
- Highway advisory radio
- Instrumentation equipment
- Medical equipment
- Flashlights
- Photovoltaic generators
- Portable AM/FM radios
- Portable pumping stations
- Radio base and repeater stations
- Refrigerators and coolers
- Security lights
- Small battery chargers
- Streetlights
- Traffic signals
- Victim detection equipment
- Water purification

Listed above are various general applications that are presently available as PV-powered. Actual applications demonstrating the usefulness of PV in disasters was presented earlier in this report. PV power can be applied to any disaster, whether a hurricane, earthquake, or technological hazard.

Meeting emergency demands in large-scale disasters, where power will be out for long periods of time and survivor support is difficult to provide due to the extensive area destroyed, are viable uses for PV. Massive infrastructure damage makes refueling generators a challenge as pumping stations are often inoperable and roads impassable. Power distribution lines are difficult to fix because of these impassable roads, much less transporting materials for reconstruction. When a disaster strikes an island and the port is destroyed, shipping fuel for generators becomes a big problem.

Solar systems are designed and sized for varying needs and applications. Since refueling is not required, length of operation poses no problem when the PV system is properly designed. Communities should be disaster resistant, both structurally and its energy resources. Solar-powered systems are a natural solution because they can be designed specifically for stand-alone operation without utility power as a critical power supply. If structures are still standing, PV can make your building or community energy supply disaster resistant.

PV is a viable source of electrical power for certain disaster relief applications such as low power needs and long term use. Electrical energy needs can vary from two watts to charge the batteries in a flashlight to 1,000 watts to power a saw. The systems can be portable when mounted on a trailer or installed in a case. Some uses, like communications and medical clinics, require quiet non-polluting operation, which PV is capable of providing. Solar energy is a valuable, cost-effective resource for small portable and stand-alone electrical power applications due to lower operating cost than gasoline generators.

5. PV RESOURCES

Even though they are not usually sold in general department stores, there are many manufacturers and distributors of PV systems and equipment. The easiest method to locate PV equipment is by a directory. Presently, there is no list of equipment specifically for disaster relief. Several directories are available as follows:

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6. CONCLUSION

Photovoltaic power systems have been used previously for disaster relief efforts and have been successfully applied to medical clinics, communication operations, shelters, and individual people needs. Each Emergency Support Function administrated by Emergency Management Operations has an electrical power need that can be provided by photovoltaic systems. Renewables, including PV, need to be addressed in local Emergnecy Management Plans to fully implement them into disaster relief efforts for the future.

Solar-powered systems are designed and sized for varying needs and applications. PV power systems provide clean, quiet electricity that does not require refueling as the sun supplies an endless supply of energy. PV is a viable source of electrical power for certain disaster relief applications that require low power, long term use, and where survivor support is difficult to provide. The stand-alone operations of solar energy systems make them a valuable cost-effective resource for electrical power due to lower operating cost and the capability for sustainable operation. In a large scale disaster, solar-powered systems are a natural solution because they are designed specifically for stand-alone operation where utility power is unavailable. PV can provide your building or community with a disaster resistant energy source, whether used as portable or building integrated systems.

However, there are inappropriate applications for photovoltaics in response to disasters. The large-scale power needs of sewer and water facilities, hospitals, large shelters, distribution and emergency operations centers are better met with gasoline or diesel generators. Locations or equipment requiring hundreds of kilowatts of emergency power would require large areas of open space and cost hundreds of thousands of dollars for PV arrays. If the location affected by the disaster is small and utility power can be restored in a short period of time, then PV may not be the correct solution. Emergency Management personnel need to understand their community energy needs and photovoltaic technology to make the right application choice.

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