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Needs Assessment for Applying Photovoltaics to Disaster Relief

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NEEDS ASSESSMENT FOR APPLYING PHOTOVOLTAICS TO DISASTER RELIEF

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Needs Assessment For
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Table of Contents

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ABSTRACT

When a disaster strikes, such as a hurricane, flood, tornado, or earthquake, it can leave many people without adequate medical services, potable water, electrical service and communications. It can be as destructive as Hurricane Andrew, which left several hundred-thousand people homeless. Those fortunate enough to survive the disaster could be without local utility power and other services for long periods of time as services are restored.

When such disasters occur, emergency management teams, the military, and many public and private organizations respond with massive relief efforts. Dependency on electrical utility power becomes pronounced as emergency services are rendered and rebuilding begins.

Photovoltaic (PV), or solar electric, systems offer a source of quiet, safe, pollution-free electrical power. PV systems are capable of providing the electrical needs for vaccine refrigerators, microscopes, medical equipment, lighting, radios, fans, traffic control devices, communications and other general electrical equipment.

This needs assessment discusses the need for electrical power during a disaster, and the capability of PV to fill that need. The report identifies the role PV technology can play in disaster relief efforts, communicates this role to government and relief organizations, utilities and the PV industry, and discusses possible ways to procure, store, maintain and deploy PV equipment in emergency situations.

1. INTRODUCTION

Hurricane Andrew struck the coast of south Florida with a tremendous destructive force on Monday, August 24, 1992. Winds of 140 miles per hour severely damaged at least 85,000 buildings, and an estimated 34,000 homes had to be replaced, leaving hundreds of thousands of people homeless in Dade County (see Figure 1). 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, in the aftermath of the storm. Shelters, medical clinics, hospitals, fire stations, and police stations also suffered damages and loss of utility services.

When such disasters occur, emergency management teams, the military, and many public and private organizations respond with massive relief and rebuilding efforts. Food, water and medical supplies are provided to survivors in the area. Workers from nearby utilities help local utility workers restore and rebuild utility power, phone and water lines and other community services.

Areas struck by disasters have many electrical energy requirements, many of which can be met by photovoltaics (PV), or solar electric, power systems. PV systems can power lights, refrigerators, traffic control devices, communications and other equipment needed when utility connection is down.

The purpose of this needs assessment report is to identify the role PV technology can play in disaster relief efforts and to communicate this role to government and disaster relief organizations, utilities and the PV industry. The overall goal of this needs assessment is to present possible ways of procuring, storing, maintaining and deploying PV equipment in disasters and other emergency situations.

Figure 1. Home Destroyed in Florida City

2. DISASTER RELIEF ORGANIZATIONS AND THEIR ROLES

Many organizations that respond to various disasters or hazardous incidents do so through an "all-hazards" management approach to protect property and save lives. All levels of government — federal, state and local— and the private sector — industry, voluntary organizations and associations — work closely together to mitigate the effects of disasters.

Local and state governments prepare and maintain a Comprehensive Emergency Management Plan (CEMP) that specifies how citizens and property will be protected in a potential disaster. The CEMP describes actions that may be required for any natural or technological hazard, including tasks to be carried out by specified organizations, administrations, and authorities. The plan may also include definition of responsibilities, standard operating procedures, logistics activities, and a list of available resources. The CEMP resource list provides both personnel and equipment requirements, including responsibility level and where these resources are available.

Mutual Aid Agreements and Memoranda of Understanding provide vehicles for local and state governments to request disaster response and recovery assistance from other local and state

governments and organizations. These agreements are also used by utilities, industry and voluntary organizations. The most widely used agreement is between the local, state and federal government and the American Red Cross to provide and maintain shelters and other services.

To effectively and safely respond to a disaster, trained, experienced individuals and organizations are called on by the local emergency management agency affected by the disaster. Only when needed, does the local emergency management call for or accept outside personnel or resources. Untrained personnel and inappropriate resources can hinder disaster recovery efforts and reduce the safety of operations.

2.1 Federal government

The federal government provides guidance and assistance to state and local governments when state and local resources are insufficient. Most federal assistance is in the form of financial loans and grants to individuals, businesses and communities, which become available after a disaster has passed. The Federal Response Plan (FRP) provides the system for the overall delivery of federal assistance. When a disaster is overwhelming to state and local governments, the federal government can be mobilized and provide support through 27 federal departments and agencies. The FRP defines the policies and procedures for federal assistance in providing necessary personnel, technical expertise, equipment and other resources. Federal disaster recovery programs and mitigation assistance are implemented under the FRP as directed by the President under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 93-288.

The Federal Emergency Management Agency (FEMA) is involved in mitigation, preparedness, response, and recovery activities as the lead organization. It provides training programs and research information on the latest mitigation measures, and reviews and coordinates state emergency plans. FEMA also provides financial assistance, coordinates federal services for disaster response and recovery activities, provides flood insurance and other programs.

Other federal departments, agencies, and national laboratories involved in disaster relief are as follows:

- Department of Energy
- General Services Administration
- Office of Foreign Disaster Assistance
- Department of Health and Human Services
- Department of Housing and Urban Development
- Department of the Interior
- Department of Agriculture
- National Communications System
- Department of Transportation

- Sandia National Laboratories
- Environmental Protection Agency
- National Oceanic and Atmospheric Administration
- Caribbean Disaster Emergency Response Agency
- Idaho National Engineering and Environmental Laboratory
- Center for Natural Disaster Response, Recovery and Mitigation: DOE
- National Renewable Energy Laboratory
- Oakridge National Laboratory
- Lawrence Livermore National Laboratory
- National Weather Service
- National Hurricane Center
- U.S. Army Corps of Engineers
- National Center for Appropriate Technology
- Center for Renewable Energy and Sustainable Technology

2.2 State government

State governments provide a comprehensive emergency management plan, programs and resources to assist local governments with preparedness and recovery activities. Each state carries out statewide emergency management activities, helps coordinate emergency management activities involving more than one community, and coordinates support from the various state agencies. The state is the pivotal point between policy guidance and resources available at the federal level and the implementation of comprehensive emergency management programs at the local level.

Some typical state government agencies involved are as follows:

- Emergency Management Agency
- Department of Transportation
- Energy Office
- National Guard
- General Services
- Department of Community Affairs

2.3 Local government

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 equipment and facilities, sanitation services, schools, supplies, and personnel capabilities to resolve prevailing problems. They must provide the initial response and assistance in a disaster.

Local governments provide protection through the following activities:

- Identify hazards and assess their potential risk to the community.
- Determine the community's ability to prepare for, respond to, mitigate the effects of and recover from major emergencies.
- Identify and employ methods to improve a community's capability through the efficient use of resources, improved coordination, and cooperation with other communities and with the state and federal governments.
- Establish mitigation measures such as building codes, zoning ordinances, and land-use management programs.
- Develop and coordinate preparedness plans.
- Establish warning systems.
- Stock emergency supplies and equipment.
- Educate the public and train emergency personnel.
- Activate response plans and rescue operations.
- Ensure that shelter and medical assistance is provided.
- Assess damage caused by the emergency.

Locally, their are various government agencies and community organizations that provide valuable resources as follows:

- Community Emergency Management Agency
- Governor, Mayor, or Community Administrator
- Local Emergency Planning Committee
- Fire Department
- Police Department
- Emergency Medical Services
- Department of Transportation
- General Services
- Department of Community Affairs
- Public Works Department
- Telephone companies
- Electric Utilities

When local governments are without sufficient resources, they can request assistance from the state or federal government. Two of the greatest response resources that the state or federal government provide are the National Guard and military services.

2.4 Industry

Industry manufactures equipment and supplies, and provides services to be used before, during and after disasters. All sorts of equipment is needed from cots to radios, portable toilets to food and more. Some equipment is obtained before a disaster and is stored or used for other things, while other equipment is obtained after a disaster to restore buildings or help people survive. In many cases, the equipment is purchased, or in some cases is rented, usually by prior agreement.
Also, there are service companies that assist in planning for future and managing present disasters.

2.5 Voluntary Organizations

Voluntary organizations supply most of the personnel needed in a recovery effort. They maintain vast amounts of supplies and equipment for relief efforts and administer donations programs. Feeding stations, clothing, mass or individual shelters, cleaning and comfort kits, first aid, blood, supplementary medical care, child care and other resources and social services are available from these organizations. Some of these organizations support the many emotional and spiritual needs of the survivors, their relatives and neighbors.

Many of the organizations supporting disaster relief are members of the National Voluntary Organizations Active In Disaster (NVOAD). Members maintain a memorandum of understanding with emergency management agencies and cooperate among fellow member organizations during disasters.

Some NVOAD member organizations include:

- Adventist Community Services
- Catholic Charities
- International Relief Friendship Foundation
- National Organizations for Victim Assistance
- Volunteers of America

A description of the NVOAD is presented in Appendix A. A complete directory with links to expanded descriptions of each member organization can be found on the world wide web at the following address: http://www.vita.org/nvoad/

Other organizations (some local) can offer specialized expertise, which can prove particularly useful in disaster relief efforts. The following list includes a sample of these:

- University of Miami Field Epidemiology Survey Team
- International Disaster Preparedness and Response Team
- Habitat for Humanity
- K-9 Search and Rescue

- United Way

2.6 Associations and other organizations

Several professional associations provide professional development, education, outreach and other services for personnel working in this field. The associations are as follows:

- National Coordinating Council of Emergency Management
- National Emergency Management Association
- Florida Emergency Medicine Foundation
- National Building Protection Council
- Medical Examiner Association
- Insurance Institute for Property Loss Reduction
- Insurance Information Institute
- Southern Building Code Congress
- National Committee on Property Insurance
- Wind Engineering Research Council
- Electric Power Research Institute
- National Association of State Energy Officials
- Association of Contingency Planners
- Florida Emergency Preparedness Association
- Emergency Management Planners
- Central United States Earthquake Consortium
- Institute of Emergency Administration and Fire Science
- Solar Energy Industries Association

A few research institutes have been established with a specific area of study. Some examples are as follows:

Disaster Research Center/Delaware - Sociology and social psychology, including scientific studies of reaction of groups and organizations in community-wide emergencies, particularly disasters and how resulting problems are solved by affected persons and communities, and response planning and mitigation policy development.

Center for Disaster Management/New York- Promotes the development and use of information science and technology for decision making and management, especially the development of effective and usable management information systems to assist New York state officials in improving emergency plans and procedures for a variety of disaster contingencies.

Some people working in emergency management or for disaster relief organizations are required to complete training for their position. Some colleges provide training and degree programs for managers, planners and others on various aspects of emergency management and disaster relief.

Some of the nationally recognized institutions that provide such programs are as follows:

- Florida College of Emergency Physicians
- Lewis and Clark Community College
- Emergency Management Institute
- St. Petersburg Junior College

2.7 Emergency Support Functions

There are short-term Immediate Response and long-term Relief Efforts teams responding to a disaster, each with its designated function. Response teams are deployed within the first 24 to 72 hours after a disaster or incident. As immediate needs and life support problems are resolved, response teams are either dismantled or are replaced with relief teams for the long-term restoration effort.

Some emergency management personnel from government agencies, voluntary organizations, industry and utilities are organized into teams to resolve specific emergency situations within a disaster or incident. The teams are organized into service areas or disaster relief activities called Emergency Support Functions (ESF). There are 17 ESFs, which manage and coordinate specific categories of assistance common to all disasters. Emergency Support Functions are organized as follows:

ESF1 Transportation - provide or obtain transportation support.
ESF2 Communications - provide telecommunications, radio and satellite support.
ESF3 Public Works and Engineering - provide support in restoration of critical public services, roads, and utilities.
ESF4 Fire Fighting - support detection and suppression of wilderness, rural and urban fires.
ESF5 Information and Planning - collect, analyze and disseminate critical disaster information to State Emergency Response Team members.
ESF6 Mass Care - manage temporary sheltering, mass feeding and distribution of essential supplies for disaster victims.
ESF7 Resource Support - provide logistical and resource support to other organizations through purchasing, contracting, renting and leasing equipment and supplies.
ESF8 Health and Medical Services - provide health, medical and social services.
ESF9 Search and Rescue - locate lost persons and victims trapped in collapsed structures and provide immediate medical care.
ESF10 Environmental Protection and Hazardous Materials - respond to actual or potential hazardous materials discharges and other situations threatening the environment.

ESF11 Food and Water - secure bulk food, water and ice to support mass care sites.
ESF12 Energy - support response and recovery from shortages and disruptions is supply and delivery of energy resources.
ESF13 Military Support - provide military resources to support logistical, medical, transportation and security services.
ESF14 Public Information - disseminate disaster related information to the public.
ESF15 Volunteer and Donations - coordinate utilization and distribution of donated goods and services.
ESF16 Law Enforcement and Security - coordinate the mobilizations of law enforcement and security resources.
ESF17 Animal Issues - Provide pet and animal shelter resources.

Each ESF is headed by a lead organization responsible for coordinating the delivery of goods and services to the disaster area, and is supported by numerous other organizations. In a disaster, the lead team in each support function calls on the various organizations committed to support that activity and need, in addition to the other support functions. They also solicit support from other organizations outside the system as needed.

2.8 Advisory Committee

The various organizations participating in disaster relief are being organized into a Disaster Advisory Committee. The purpose of this committee is to assist in obtaining information on the energy needs of the disaster relief industry, obtain ideas for PV applications and provide advice on applying PV to disaster relief efforts. These representatives will be incorporated into the PV Committee of 500 (PVCO500), an online advisory committee operated by FSEC for the Photovoltaic Southeast Regional Experiment Station (SE RES).

3. PROCURING, STORING AND DEPLOYING DISASTER RELIEF EQUIPMENT

Currently, procuring, storing, and deploying procedures are defined in an emergency plan that each organizations must maintain. These three tasks may be carried out by the organization itself, contracted out, or provided by another organization. The type of organization and the type of equipment determine the procedures for procuring, storing, and deploying resources in a disaster, usually defined in the plan.

3.1 Procurement

Disaster relief organizations use various methods to obtain the equipment to fit their needs. Funding to procure this equipment may come from many sources, such as donations, taxes, and other agencies. The federal government obtains equipment, employs personnel, and administers programs through taxes. Local and state governments purchase most of their equipment from local taxes, but some funds come from federal programs and grants. Non-profit organizations depend on donation, grants, and other agencies.

Most organizations follow similar procurement procedures. They have general funds for day-to-day operations and have to budget for new equipment purchases each year. In a time of special need, other procedures are used for funding purchases, such as grants and Mutual Aid Agreements. As an example, the Florida Salvation Army Chapter this year won a State grant to purchase four portable multi-stall showers. Seven grant programs address disaster or emergency management efforts across the country and the State of Florida conducts one of its own. Typically, organizations budget new equipment each year or for other periods of time.

Specialized or hard-to-obtain equipment is purchased so it is readily usable by that organization. Some equipment is rented as needed through predefined agreements, special contracts or Mutual Aid Agreements.

3.2 Storage

Disaster relief organization have similar methods for storing equipment at local, regional, and national storage centers. Some equipment is used only during disasters and is stored for long periods of time (for example, cots). Other equipment is multi-use. For example, lighted road signs can be used throughout the year and be dedicated for disaster relief as needed. If equipment is rented, the organization does not store it at all; the rental organization stores the equipment. For example, portable outdoor toilets are usually rented from companies outside the disaster area. Naturally, the shelf-life of an item defines its storage capacity. Perishable or consumable resources are usually not stored, but obtained as needed. Some equipment requires maintenance, which affects its storage capacity, such as radios that use batteries or those items stored outside.

The amount and size of the equipment has an effect on storage capabilities. For large equipment such as a semi-trailer refrigerator, one unit fills a large area. Any number of large items can be a storage problem, as an area the size of a football field may be needed.

An important consideration is where to store equipment out of harm's way. For example, in Florida hurricanes cross the state anywhere and no location is safe from destruction. If a storage area is in the path of a hurricane, where should the equipment be relocated to and how long will it take to move it?

The Salvation Army in Florida has 42 chapters across the state and their Florida Regional Office is in Tampa. Each chapter maintains a canteen, which is a van equipped with a kitchen for feeding at disaster and other locations. The regional office stores refrigerator trucks, comfort stations, portable showers, and generators. They store various amounts of equipment at the national center. Several non-profit relief organizations follow a similar program.

3.3 Deployment

Deployment of equipment in a disaster depends on the type of disaster, the size and seriousness of the disaster, and which organizations are involved. Each organization follows its Emergency Management Plan, starting with the local community government. When a disaster strikes, the local Emergency Management Officials of the county activates the local Emergency Operations Center (EOC), coordinates all local disaster response actions, and coordinates utilization of outside resources with the State Emergency Response Team (SERT). The local Emergency Management Officials and the Board of County Commissioners assess the situation and declare a local state of emergency if the disaster requires outside assistance. In an emergency, State Area Coordinators act as on-scene liaison between local government officials and the State Coordinating Officer (SCO) at the State Emergency Operations Center for the Department of Emergency Management (DEM). The Governor, working with the SCO, authorizes the use of state resources, declares states of emergency, and communicates with the President to request a federal disaster declaration if state and local resources are inadequate. If required, the President of the United States, working with the Director of the Federal Emergency Management, declares the area a federal disaster and authorizes federal assistance.

When conditions indicate a disaster or hazard is imminent, the local organization activates a warning point or station to monitor the event closely. When the disaster is at hand, the ECO is activated and support staff is alerted. After the disaster has occurred, the local government emergency and disaster relief organizations assess the situation and determine the need to request assistance from state or regional organizations. If required, the state and regional organizations request assistance nationally.

After a disaster is declared, equipment and resources are deployed according to each organization's emergency plan. Mutual Aid Agreements and predefined contracts are activated. First, local equipment is deployed to the scene and regional equipment is brought into staging areas. As resources are consumed, replacements are brought in from outside areas under the direction of the state and regional coordinators. When the emergency subsides and as recovery progresses, equipment and other resources are returned.

As an example, the local chapter of the American Red Cross in Brevard County would monitor conditions and notify the regional disaster response office in Tampa. After evaluating the situation, the regional office would activate the Warning Point staging area in Orlando and the ESF 6 in the EOC in Tallahassee. These efforts would be coordinated with local and state governments according to their emergency plans. The national disaster office would be notified and everyone would stand

by. If the disaster occurs and resources are needed, the state EOC coordinator for the American Red Cross would coordinate activities between the local chapter, the Warning Point and National Disaster Headquarters in Falls Church, Virginia. Headquarters would then request assistance from other state chapters as needed.

4. NEED FOR ELECTRICITY

Many organizations' disaster response activities require electrical power. As an example, the American Red Cross provides shelters which require electrical power for lights, fans, radios, air conditioning, refrigerators and various other equipment.

Emergency Operation Centers require large amounts of electrical energy and have generators 25 kW or larger. Their centers usually have 20 or more personnel directing the recovery efforts. Telephones, fax and copy machines, lights, fans, computers, radios and other equipment are constantly in use, as shown in Figure 2.

Figure 2. Emergency Operation Center

Feeding stations depend on natural gas and propane for cooking; therefore, the main demand for electrical power is for refrigerators, lighting and fans. Resource Distribution Centers are medium power users and usually only have lights and radios for communications.

Power needs for transportation are very different than power needs for a facility. Power is needed for traffic lights, street lights, changeable message signs, arrow boards, highway radio advisory systems and many other individual devices.

Organizations have experience with their present disaster relief equipment and have developed procedures defining operation and support needs. They have provided for generators or utility

power to satisfy their equipments' electric power needs. They maintain resource lists providing size and quantity of electric power equipment, including fuel consumption information. The equipment is prioritized to identify the most critical items and energy needs. The real need for electric power is not defined by energy units consumed, but by resource defined and stored.

Over the past few years product information has been collected and actual equipment use has been observed to generate a database of electrical power needs for disaster relief equipment. The following table provides typical power requirements for each type of device for each ESF. These power requirements take into consideration differences in manufacturer and sizes used by the various organizations.

Table of Power Requirements

Device	Power requirement
ESF 1.Transportation	
Portable highway changeable message signs	500 W
Portable highway advisory radio	160 W
Street lights	120 W
Portable arrow board signs	80 W
Flashing barricade lights	1.5 W
Portable information services radio	160 W
ESF 2. Communications	
Portable Cellular phones	20 W
Call boxes	20 W
Operational base station radios	150 W
Hand-held portable radios	5 W
Radio relay stations	250 W
ESF 3. Public Works	
Portable sump pumps	600 W
Small portable DC power tools	100 W
ESF 4. Fire Fighting	
Portable pumping stations	600 W
ESF 5. Information and Planning	
Cellular phone and battery charger	5 W
Facility power	1000 W
Portable AM/FM radios and TV	10 W

ESF 6. Mass Care	
Flash lights	1.5 W
Portable AM/FM radios	1.5 W
Small battery charger	5 W
Outside security lighting	120 W
Inside lighting	500 W
Portable refrigerators	500 W
Water purification	500 W
ESF 7. Resource Support	
Communications equipment	250 W
Portable PV generator	600 W
ESF 8. Health and Medical	
Flash lights	1.5 W
Small battery chargers	5 W
Facility power	600 W
Outside security light	120 W
Inside lights	500 W
Medical equipment PV generator	500 W
Portable refrigerators	500 W
Water purifications	240 W
Water heater	1000 W
Communications equipment	240 W
ESF 9. Search and Rescue	
Flash light	5 W
Small battery charger	5 W
Sensing equipment	260 W
Communication equipment	240 W
ESF 10. Environmental Protection and Hazardous Material	
Sensing equipment	260 W
Outside security light	120 W
Communications equipment	240 W
ESF 11. Food and Water	
Portable refrigerators	500 W
Outside security lights	120 W
Inside lighting	300 W

ESF 12. Energy	
Mobile PV generators for AC	1000 W
ESF 13. Military Support	
Mobile PV generator	1000 W
ESF 14. Public Information	
Cellular phone and battery charger	5 W
Facility power	1000 W
Portable AM/FM radios and TV	10 W
ESF 15. Volunteer and Donations	
Outside security lights	120 W
Inside lighting	300 W
ESF 16. Law Enforcement	
Outside security lights	120 W
Inside lighting	300 W
Communications equipment	600 W
ESF 17. Animal Issues	
Outside security lights	120 W
Inside lighting	300 W
Water purifications	240 W

5. SURVEY OF ELECTRICAL ENERGY REQUIREMENTS

To complete the needs assessment, quantitative and operational information needs to be collected on the electrical power requirements and the role of PV technology in disaster situations. The information can be collected through observations, surveys, and experimentation. FSEC has participated in a number of disaster relief efforts and has observed first-hand the types of equipment used by different relief organizations. Several demonstration experiments have been completed in actual disaster providing valuable first hand information. Also, data needs to be collected systematically from representatives of participating organizations and individuals.

A survey was conducted to document actual needs and uses of electrical power. The survey form asked for the following information:

- Do you have any knowledge of photovoltaic and renewable energy resources?
- To what types of disasters does your organization respond?
- For what duration does your relief effort usually last?
- For what type of equipment do you require electrical power, and how many of each do you have?
- What type, size and quantity of electric generators do you presently use?
- How does your organization store and deploy its equipment?
- Demographics — organization name, location, etc.

The survey form was distributed at the Energy Supply Disruption Workshop in the Virgin Islands, and the Florida Governors's Hurricane Conference in Tampa, and mailed to members of the advisory committee. Conference attendees who did not have the detailed information with them selected to complete the form later and send it to FSEC. Many of the respondents did not complete all of the questions. Of the 300 forms that were distributed, 49 were returned. Of those surveyed, 83 percent were professional disaster relief workers with 27 percent of them having national and 29 percent regional affiliation.

In addition, the survey form was placed on the FSEC web home page for other interested parties. A copy of the survey form is in Appendix B.

The survey indicated that 95 percent used no alternative fuel generators; 3 percent used propane; and 2 percent used PV. Of the various types of disasters, hurricanes and floods were responded to most. In response to these disasters, the longest time without conventional electricity was over 6 weeks with most of the respondents being without electricity between 2 to 6 weeks. About half of the respondents were without conventional electricity for over 3 days after the disaster. Tabulated results of the survey are in Appendix C.

It was hard to determine the type and size of generators respondent were using because of the naming convention and sizing of portable, mobile, and stationary generators on the survey. There were some 5 kW generators on trailers and some 10 kW generators not on trailers and other mixing of size and type. The quantity and type of generator was the least answered question. Actual inventory lists are being requested from the various organizations.

6. PREVIOUS USAGE DURING DISASTERS

In recent years, the PV has been introduced to emergency management organizations by members of the PV industry and avid users. A detailed description of recent uses of PV in disaster can be found in the report, "History of Applying Photovoltaics to Disaster Relief," document number FSEC-CR-934-96. PV has supplied emergency power for relief efforts for the following disasters:

Disaster	Year	Power out
Hurricanes Hugo in St. Croix and S. Carolina	1989	Weeks
Hurricane Bob in Rhode Island	1991	Days
Earthquake in Northridge Southern California	1991	Days
Hurricane Andrew in Miami	1992	Weeks
Hurricane Erin in Central Florida	1995	Days
Hurricane Luis in Virgin Islands	1996	Weeks
Hurricane Marilyn in Virgin Islands	1996	Weeks
Hurricane Iniki in Hawaii	1996	Weeks

The most widely used application of PV was for communications and lighting. Some of the PV systems were existing when the disaster struck and operated afterward, such as lighting systems, stand-alone homes, and traffic devices. Half of the systems were carried into the disaster by hand or on trailers.

The following table gives a brief description of the known PV systems used in disasters:

Description	Disaster	ESF
Portable tote used for lighting and communication at shelters	Hugo	2
Trailer-mounted PV system for lighting and communications	Earthquake	2
Portable PV system for amateur radio station at a shelter	Andrew	2
Portable PV lanterns at homes and shelters	Andrew	6
Fixed ground mounted PV array on residence in Rhode Island	Bob	6
Roof mounted PV system on building in Cape Canaveral	Erin	12
Roof mounted PV on rentals at resort in Virgin Island	Luis	6
Fixed PV system at medical clinic in Miami	Andrew	8
Trailer mounted PV generator at orphanage in South Carolina	Hugo	6
Security lights around buildings in Brevard County	Erin	16
Trailer mounted highway advisory radio in Miami	Andrew	2

Water purification systems in Virgin Islands	Luis	11
Trailer mounted changeable highway message sign	Andrew	1
Portable PV systems to power radios in Virgin Islands	Luis/Marilyn	2

7. APPROPRIATE ROLE AND RECOMMENDED APPLICATIONS FOR PV

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 is very important to emergency personnel who need 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 stand-alone 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.

The following list gives many of the various general applications that are presently available PV-powered.

- Building or back-up power systems
- Call boxes
- Flashing arrow boards and signals
- Changeable message signs
- Folding man packs
- Hand-held radio transceivers
- Highway advisory radio
- Instrumentation equipment
- Medical equipment
- Flashlights
- Portable generator systems
- Portable AM/FM radios
- Portable pumping stations
- Radio base and repeater stations
- Refrigerators
- Security lights
- Small battery chargers

- Street light
- Victim detection equipment
- Water purification

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, PV can be a viable source of electrical power. Massive infrastructure damage makes generator refueling a challenge, as pumping stations are often inoperable and roads impassable. Power distribution lines are difficult to fix because of these impassable roads, which hinder the transport of personnel and materials for reconstruction.

Communications equipment and medical clinics, which may require quiet, non-polluting operation, are other examples in which PV is viable. Makeshift shelters and temporary medical clinics are set up in buildings that received little damage and are safe to occupy. They need electrical power to provide medical services to injured people. Personnel may need to deal with issues such as disease control, producing a need for vaccine refrigerators. They may also need electricity to provide hot water, to sterilize instruments and to power equipment for laboratory work.

Recovery efforts are hampered by the loss of local business and services, both when buildings are destroyed and when an area simply loses electrical power. In turn, if these are long-term losses, they can damage the local economy, as people lose jobs. Business and vital services can benefit from building-integrated systems that allow them to resume operations sooner.

Portable and stand-alone electrical power applications are yet other examples in which PV can be cost-effective, as smaller systems may have lower operating costs than gasoline generators.

Solar systems are a natural solution because they are designed specifically to operate without utility power. Solar systems are versatile — they can be designed and sized for varying needs and applications. They are also sustainable — they require no refueling, so length of operation poses no problem as long as sunlight is available.

Mobile PV systems mounted on trailers can be easily deployed to power medical clinics and provide communications. PV lighting systems can be installed for security at shelters and facilities for security either before a disaster or after. Portable tote PV generators when used by search and rescue teams can reduce load requirements as PV is fueled by the sun. PV powered warning sensors and systems, such as weather stations provide benefits both before, during and after a disaster.

8. PROCUREMENT OF PV

In general, emergency management and disaster relief organizations have well established programs and procedures for obtaining equipment, and the purchase of PV-powered equipment can be made as part of their normal purchasing process. Several federal and state emergency management funding programs are already available, and new grant or cost share program could be initiated by the government.

The insurance industry is interested in reducing costs and could develop programs to reduce insurance rates or offer cost sharing. Utilities and the PV industry could also provide programs for leasing, renting or purchasing PV systems for disaster relief and recovery.

9. CONCLUSIONS

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. PV-powered systems can be 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 standalone 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 standalone operation where utility power is unavailable.

There are, however, inappropriate applications for photovoltaics. 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. Facilities 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.

Many of the Emergency Support Functions have an electrical power need that can be provided by photovoltaic systems. The various emergency management and disaster relief organization can purchase, store and deploy photovoltaic systems just as they do their present equipment. As PV becomes implemented into existing disaster organization procedures and various emergency management plans, it will become an accepted everyday tool.

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APPENDIX A

Voluntary Organizations

APPENDIX B

Needs Assessment Survey Form

APPENDIX C

Survey Results