Photovoltaics: Disaster and Energy Security Applications

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ABSTRACT

The modernization of our lives with the use of electronic devices has contributed to a steadily increasing dependence on electric power. The degree of importance of electricity is temporarily highlighted with any type of power outage, whether caused by an accident, a natural disaster or a terrorist attack. A disaster can leave many people without adequate medical services, potable water, electrical service and communications.

There is a value in applying photovoltaics (solar electric) to create disaster-resistant buildings and communities, which is to reduce losses and improve quality of life. Photovoltaics provide a viable source of electric power for energy security and disaster relief applications.

PURPOSE

A disaster, natural or man made, can happen at any time, disrupting the normal daily community routine. In the past, natural disasters, such as hurricanes, floods, tornados, lightning storms and earthquakes have been our major concern. Now, man made disasters such as nuclear mishaps, hazardous material spills and terrorist activities have become an ever increasing threat. Weather- related events provide some type of advance warning, while earthquakes, hazardous material disasters and terrorist attacks do not.

A disaster can leave many people without shelter, adequate medical services, potable water, functional sewage systems, electrical service and communications for long periods of time. 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. Not only can lives be destroyed, but communities, businesses and the environment can be impacted. In our modern society, we have become dependent on electricity, as electronic devices are an integral part of our daily lives. The degree of importance of electricity is temporarily highlighted with any type of power outage. On August 14, 2003, over 50 million people in the Northeastern part of the United States experienced one of the largest and longest lasting utility blackouts in history.

On August 24, 1992, Hurricane Andrew struck south Dade County, Florida, USA, with winds over 120 miles per hour. The storm damaged over 85,000 buildings and more than 200,000 people were left homeless. More than 12,000 miles of power lines were destroyed, leaving 1.4 million people without electricity for days and weeks after the storm. Over 8,000 gasoline and diesel generators were used in the recovery process.

On September 11, 2001, terrorists destroyed the Twin Towers and several adjacent buildings in New York City, USA. Over three thousand people lost their lives and eight city blocks were damaged in that event. Over one hundred gasoline and diesel generators were used to power search and rescue equipment in an effort to find survivors and remove debris.

Nearly every country has an organization that prepares for and responds to disasters. That organization has a plan for organized, comprehensive handling of disasters and hazardous events. Response and recovery efforts are structured to resolve emergency situations and provide resources for emergency functions such as those listed in Table 1.

Table 1. Emergency Support Functions

Transportation	Communication
Public works/engineering	Fire Fighting
Information/Planning	Mass Care
Resource Support	Health/Medical
Search and Rescue	Energy
Hazardous Materials	Food/Water
Military Support	Public Media
Volunteers/Donations	Law/Police

Medical, fire and police services are needed immediately after a disaster and during the period of reconstruction. Communication is critical to emergency personnel in order 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 would require varying amounts of electrical power.

APPROACH

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, such as PV lighting.

From an emergency management aspect, disaster-resistant buildings and communities are the ultimate goal. Disaster resistance should have a meaning that reaches beyond creating a building that can physically withstand the forces of a disaster. Building design should provide sustainable operational use after the disaster if the building is still standing. The home or business owner would need utility services or a self-sustaining energy system to continue use. Reducing damage and losses reduces the amount of response and recovery effort needed.

From an energy security aspect, zero energy buildings would have energy production in close proximity to the load and would provide energy generation equal to consumption. On-site generation with renewable energy sources would provide consumers energy assurance in a disaster as well as in normal daily life. If excess generation is produced, it can be redistributed to the utility company or to other loads.

The Florida Solar Energy Center, Sandia National Laboratories and the National Renewable Energy Laboratory have jointly researched the application of photovoltaics (solar electric) in disasters. As a renewable energy source, photovoltaic (PV) is an environmentally benign, inexhaustible source of electrical energy. Solar powered equipment requires no fuel and is less expensive to operate than gas or diesel generators. PV modules are modular allowing various outputs. In order to be a disaster resistant or zero energy building, a structure needs to maximize energy conservation. The more energy conserved, the less energy that needs to be produced. The next thing to do is to use distributed energy generation where more than one energy source is used. If one or more sources have failed, one or more of the other energy sources would supply the energy needed for the load. The use of various renewable energy sources, such as photovoltaics, is needed to ensure sustainability. By implementing an integrated approach to critical energy issues, energy providers and consumers can collectively assure an improved level of energy security and reliability.

The need for electrical power and the priority for those needs during disasters should be evaluated for effective use of renewables. There is a need to understand and apply disaster resistant and fault tolerant architectural concepts in equipment, buildings and communities to reduce losses and improve quality of life. The PV industry needs to provide effective systems for response, recovery and mitigation in a disaster and disaster organizations need to properly use viable photovoltaic systems as a reliable source of energy.

SCIENTIFIC INNOVATION AND RELEVANCE

There had been limited use of photovoltaics in disasters until 1989, when Hurricane Hugo struck the state of South Carolina, USA, at which time a trailer mounted, PV-powered generator was transported to the devastated area to assist with relief efforts. Photovoltaics had been introduced to emergency management organizations by members of the PV industry and a few enthusiasts. Since then, a variety of PV-powered applications have been demonstrated in various emergency support functions. In recent years, PV has supplied emergency power following Hurricanes Hugo, Andrew, Mitch and Luis as well as after the Northridge Earthquake in Southern California, USA.

Several years 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. In response to Hurricane Luis, Miox Corporation provided PV-powered water purification units to the Virgin Islands, USA. The units produce hundreds of gallons of potable water each day.

Listed in Table 2 are various general applications that are presently available as PV-powered equipment.

Table 2. Equipment Applications

Building or backup power
Call boxes
Flashing arrow boards
Flashing warning signals and signs
Folding man power 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
Pipeline leak detection
Utility control and monitoring
Emission monitoring
Surveillance and monitoring equipment
Critical power supply.

PV power can be applied to any disaster, whether a hurricane, earthquake, technological hazard or terrorist attack. A viable use for PV is to meet the 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. 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 the 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 problem.

Military installations currently use PV to power surveillance and monitoring equipment. Utilities and businesses are now using PV to protect their facilities. These fixed applications benefit from the capabilities of PV. PV stand-alone operation makes them valuable for energy security applications for monitoring, detecting, surveillance and controlling materials, resources, and utilities. For years PV has been used for instrumentation, such as in weather stations, and is now being applied in a similar manner for security applications.

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 in energy resources. For added energy assurance, PV can be one of the energy sources in a distributed generation system. 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 after a disaster, PV can serve as a critical power supply or back-up system.

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 portable case. Some uses, like communications and applications in 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 since it offers lower operating costs than gasoline generators.

Consumers, both homeowners and businesses, need to evaluate their energy needs and operational activities. Identifying critical energy needs and incorporating the concept of critical power supply design into a home or commercial building would ensure needed power to maintain key operations. During a power outage, a homeowner may want to have electricity for a lamp, operating a refrigerator and a radio. A business may need a few lights for safety and a cash register to complete sales. Most consumers would consider these items critical to maintaining business operations and personal lifestyle until power is restored. Small electrical and electronic devices can be powered through backup power sources. This can be accomplished by connecting a sub panel to the main power panel. The sub panel would then be powered by an alternative energy source, such as a PV system, wind, small hydro, solar thermal, microturbines, geothermal or a hydrogen fuel cell generator. This design concept integrates a distributed energy source to a specific load, assuring energy security.

RESULTS

Studies and experience has shown that PV plays an important role in response, recovery and mitigation in disasters. Portable systems under 1 k-Watt meet many of the needs of disaster organizations in response efforts, where 1 to 5 k-Watt systems provide critical stationary power. Small utility-interactive PV systems with battery backup increase the effectiveness of disaster resistant buildings and ultimately support communities in the power mix for distributed generation.

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 in an emergency. 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. There are thousands of PV systems around the world, but only a few in the megawatt range. 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 for response efforts. Emergency Management personnel need to understand their community's energy needs and photovoltaic technology to make the right application choice.

CONCLUSIONS

While people in the industrialized world are dependent on utility providers to meet energy needs, it is the right and the responsibility of each person to become aware of energy security issues and to accept a shared accountability for meeting personal and collective energy needs. Meeting personal energy needs has been a way of life for people in developing countries and that responsibility is returning to industrialized countries as threats of disasters and energy shortages have broader implications and impact.

Many PV systems are available and many applications needing power. The trick is to apply the right system to the right application. Understanding users' needs is important to successful applications of PV by the industry. PV can provide energy assurance as well as energy security. In order to assure energy availability, renewables, including PV, need to be addressed in local Emergency Management Plans and Emergency Energy Plans.

Photovoltaics is a viable source of electrical power for many disaster relief and energy security applications. This has been proven in many successful demonstrations over the years. Solar-powered systems are a natural solution because they can be designed specifically for stand alone operation and the sun supplies an inexhaustible source of electrical energy.

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