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Photovoltaic Use In A Disaster: Mitigation Verses Response

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Abstract

Natural disasters can happen at any time destroying lives, homes, businesses and the natural environment. In their path they leave many people without medical services, potable water, electrical services and communication for long periods of time. A disaster can be a minor or major incident impacting the people that survive its effect. We all become aware of the destruction caused by major hurricanes such as Katrina leaving several hundred-thousand people homeless and the resources needed to respond to save lives and restore property. In the midst of these extraordinary complications, emergency management teams, medical personnel, the military, and countless public and private organizations participated in the massive relief effort costing into the billions.

With each disaster, plans, procedures, building codes, funding and organizations change as new lessons are learned in responding to each disaster. The best way to respond to a disaster may be to mitigate the effects of a disaster. One solution to minimize this type of destruction and the disruption to our lives is the implementation of disaster resistant buildings that are fortified to the latest codes, energy efficient, and incorporate renewable energy systems, such as photovoltaics.

Keywords: Disaster, Renewable, Photovoltaic, Mitigation, Response.

Introduction

Natural and man made disasters can happen at any time with little or no warning. Such events can leave many people without medical services, potable water, sanitation, electrical services and communication for long periods of time. Disasters can be as destructive as the 2004 SumatranTsunami, the Earthquake in Afghanistan or Hurricane Katrina destroying lives, homes, businesses and the natural environment, leaving several hundred-thousand people homeless. Now, man made disasters such as nuclear mishaps, hazardous material spills and terrorist activities have become an ever increasing threat. Disasters can be as minor as an afternoon thunderstorm knocking down local power lines to our home disrupting our daily lives. 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.

Purpose

After each major disaster, a massive relief effort is organized by emergency management teams, medical personnel, the military and countless public and private disaster response organizations. To provide medical, fire, and police services, makeshift shelter and medical clinics are usually set up in buildings that had managed to withstand the forces of the disaster. The immediate goal is to provide life-support resources. Usually, massive amounts of water, food, and medical supplies pour into the disaster area from across the country and the world. However, despite the resources and donations and the efforts of hundreds or thousands of volunteers, the destruction may be so overwhelming, that it would be months or years before the area could be restored, even partially, to its pre-disaster condition. To make matters worse, the entire relief effort, (including the rebuilding of homes and business), is seriously hampered, because the usual services of potable water, sewer, and electricity had been severely affected, if not obliterated, by the disaster.

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.

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 September 26, 2004, the 2004 Sumatra Tsunami in the Indian Ocean was the second largest earthquake ever recorded with waves up to ten meters. Over 226, 000 people died and over 1.5 million were left homeless in eleven countries.

On August 28, 2005, Hurricane Katrina struck Florida, Louisiana, Mississippi, Alabama, USA. Over one thousand people lost their lives and 130 thousands buildings were destroyed. Over 3 million people were without electricity.

We cannot stop or control disasters, which will have lasting effects on both people and property. We can prepare for all types of hazards and take measures to minimize their damage or avoid it complete. There are organizations and programs that will try to help you, but you need to be ready as well, as you are on center stage until help arrives. It is important to be able to provide for yourself for at least three days until help arrives. Disaster plans and programs define processes to follow in the four phases of emergency management; preparedness, response, recovery and mitigation.

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.

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 on people's daily lives. While people in the industrialized world have become dependent on utility power providers to meet their energy needs, it should be 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.

The effects of a disaster can be dealt with in many ways. One way is to react to a disaster by stockpiling massive amounts of recourses, such as water, food, clothing, tarps, and generators, that can be deployed after a disaster by hundreds or thousands of workers and volunteers from government and many relief organizations. This can be followed by a massive recovery process that will take months or years to rebuilds communities, business, and peoples lives and will cost millions or billions of dollars.

Another way to deal with disasters is to plan ahead and try to mitigate the effects of future disasters. Nearly every community, state, and 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. Because each disaster is unique and it impacts each community differently, there will always be response and recovery efforts. The new shift in this process is to concentrate on mitigating the effects of a disaster rather than respond to its effects. Put your money into mitigation in a pro-active way instead of responding to disasters in a massive way.

Approach

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, quite, inexhaustible source of electrical energy. Solar powered equipment requires no fuel and is less expensive to operate than gas or diesel generators. The lack of operating refueling stations makes PV even more beneficial in a disaster. PV modules are modular allowing various outputs. 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.

All four phases of emergency management will need to be practiced to safe guard people and property. The direction to follow is to do more preparedness and mitigation and less response and recovery, but yet provide for the safety, health and human needs of the people. If all of the buildings were truly disaster resistant, then there would be no need for response and recovery.

The trick would be to wave a magic wand and turn all of the existing buildings into disaster resistant buildings, but that would be impossible. The next best thing would be to build all new buildings that way, but what about the existing buildings. This change will take time, so until then response and recovery will still be practiced. Until then, many life support resources will be needed to perform response and recovery activities and renewables can play a role too. Stand alone electrical systems powered by photovoltaic would be a valuable resource after a disaster and for energy security applications.

But the ultimate goal from an emergency management aspect is disaster-resistant buildings and communities to reduce losses and improve quality of life. 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 every day use.

From an energy security aspect, zero energy buildings would have energy production in close proximity to the load and would provide at a minimum 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 through net metering.

In order to be really disaster resistant, a structure needs to be zero energy building which maximize energy efficiency and offers conservation practices. 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 and solar hot water, 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. Electrical energy needs can vary from two watts to charge the batteries in a flashlight to 1,000 watts to power a saw. 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

The first recorded use of PV in a disaster was in 1989 with Hurricane Hugo, South Carolina, USA. Since then, there has been a growing interest and implementation of PV in all types of disasters. A variety of PV-powered applications have been successfully demonstrated in various emergency support functions in response and recovery. This past hurricane season has shown the PV can also be a valuable mitigation tool.

Studies have shown that 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. 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. Since refueling is not required, length of operation poses no problem when the PV system is properly designed. Systems are designed and sized for varying needs and applications.

Over the years, PV has proven itsself in low power response and recover activities. Portable hand carried units and trailer mounted systems are now used extensively in a disaster or as well as normal times. Solar powered consumer items, such as flashlights, and radios, are available. 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.

This past 2004 and 2005 hurricane season has proven solar power, especially PV, as a valuable tool to mitigate losses before, during and after a disaster. 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.

The most valuable application for PV and renewables in general is with disaster resistant buildings and communities. Buildings should be disaster resistant, both structurally and functionally. For added energy assurance, PV can be one of the energy sources in a distributed generation system with the utility or your own home. 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 or backup power system. If structures are still standing after a disaster, PV can design to be still standing too.

As a mitigation tool, 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. Many 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

Information collect with each disaster verifies that PV, as well as renewables, plays an important role in response, recovery and mitigation in disasters. Systems have survived the forces of hurricanes when designed properly and to code. Table 1 shows levels of application of PV for normal use as well as in a disaster. Portable consumer PV systems under 1 k-Watt still meet many of the needs of disaster organizations in response and recovery efforts.

Table 1. Levels of photovoltaic generation

Level	Item	Description	PV Power
1	selected items	outdoor lights, pump, gate control	0-200 W
2	critical items	refrigerator, light, radio, register	200-1000 W
3	backup power	lighting, kitchen, water supply, systems	500-2000 W
4	zero energy	production equals consumption	2000-20+Kw
5	producer	net generator beyond consumption	10-100+ kW

The greatest benefit of PV and renewables is building integrated systems for zero energy homes that are disaster resistant. In this type of application, 1 to 5 k-Watt systems power the whole building or at least provide power to critical items. Small utility-interactive PV systems with battery backup increase the effectiveness of energy efficient 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 if the whole facility it to be powered. 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

As our population grows, so grows the need for power. People in the industrialized world are presently dependent on utility providers to meet energy needs as people become more and more dependent on electronic devices. Developing countries are moving faster and faster to becoming modernized and demanding more energy. As threats of disasters and energy shortages affect all cultures and ways of live, the future may bring a return to past practices where 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.

There are many viable portable PV systems available for response and recover. The trick is to apply the right system to the right application. Understanding users' needs has always been important to successful applications. The market is driving the implementation of PV into disaster operation rather than through incorporation into Emergency Management Plans.

PV and other renewables can provide energy assurance as well as energy security. Implementation of operational disaster resistant buildings is the ultimate tool to mitigate the losses from disasters and improve our quality of life. If all buildings were energy efficient zero energy buildings that were structurally sound and power by renewables, disaster would have little impact on our lives. This concept is viable during normal times as well as during disasters and has been proven in many successful demonstrations over the years.

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