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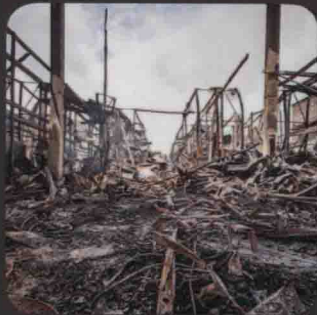
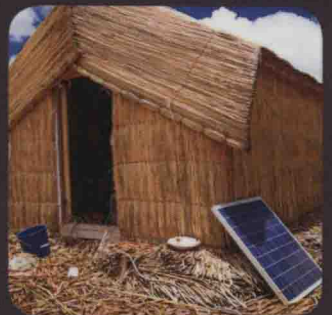


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STANDALONE PHOTOVOLTAIC (PV) SYSTEMS FOR DISASTER RELIEF AND REMOTE AREAS

SALAHUDDIN QAZI



Standalone Photovoltaic (PV) Systems for Disaster Relief and Remote Areas

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Standalone Photovoltaic (PV) Systems for Disaster Relief and Remote Areas

Dedication

**This book is dedicated to my late parents,
brother Aftab, and my siblings.**



Preface

This book addresses the use of photovoltaic (PV) systems to bring electricity for specific disaster relief and for general supply in remote areas of the world. I was inspired to write this book after realizing that the sunlight striking the earth's surface in just 1 hour delivers more energy than the entire world uses in 1 year. Ironically the countries that get maximum sunlight are currently using very little sunlight to generate electricity despite ever-increasing power shortages that harm their economies. Many of these countries also suffer from unreliable electrical grid supply with frequent power outages, leaving the population even more prone to natural disasters. I grew up in one of these countries.

When natural disaster strikes, local electrical power in most cases is the first utility affected. Disruption of electricity can last for weeks as transmission lines are slowly repaired, causing deaths and economic loss. In 2013, the United Nations reported that in the past 20 years approximately 4.4 billion people have been affected by natural disasters that claimed 1.3 million lives and cost the world \$2.0 trillion in economic loss. In the aftermath of these disasters, the PV systems can bring natural, reliable power to places recently devastated. PV systems in the standalone mode can also provide electricity for more than 1.3 billion people worldwide who do not have access to grid electricity. This figure includes more than 500 million people in Sub-Saharan Africa, more than 300 million in India, and approximately 2.6 billion people who use pollutant-emitting wood, biomass, or dung for cooking and heating their homes. For increasing the affordability and cutting the costs of rather expensive PV systems, some countries in the developing world are giving incentives through micro-financing institutions and solar companies that couple their solar products with financing plans, based on customer income. In the United States, new partnerships are emerging between citizens, electrical utilities, and governments to deliver electricity for low-income households at a reduced cost. In 2015, the White House announced that 68 cities, States, and businesses have signed up for an initiative to promote community solar with an emphasis on low- to moderate-income households.

Global installation of solar PV is expected to reach 64.7GW in 2016, with the largest market being China at 19.5GW capacity, followed by the United States and Japan. The new international solar energy alliance of 120 countries announced at the Paris COP21 Climate Summit indicates the importance of solar energy, its application to clean energy, and poverty alleviation for millions

of people living in the developing world with no access to the grid. Under this alliance, India plans to install 175 GW of renewable energy by 2022 to provide electricity to each Indian household. In the Middle East, Dubai announced a large program of mandating to install solar panels on all rooftops by 2030 as part of a plan to make the city a global clean energy center.

This book of mine is an introduction to various PV systems that can meet the immediate needs of heating, cooling, and lighting homes and businesses in the aftermath of a disaster. The book also shows ways that PV systems can deliver electricity to remote areas for everyday living including pumping water, purifying water, powering medical clinics, powering cell phones, powering mobile communication base stations and powering other facilities for off-grid areas. The book contains less mathematical derivations, cites more case studies, examples of practical PV systems, figures, software tools, databases and appropriate websites to supplement the chapter topics. This hands-on approach makes the book a must-read for designers, installers, students of renewable energy programs, policy makers, non-governmental organizations and all other people working in disaster recovery programs. It serves both the technical and non-technical readers. The book cites the names of many organizations and corporations that have developed products for PV systems, software tools, databases, and websites. The mention of a specific company name or product must not be misunderstood as an endorsement of any products nor suggest that any product is superior to another.

Chapter 1, Photovoltaics for Disaster Relief and Remote Areas, discusses differing types of natural disasters, their effect on peoples' lives and on the world economy, their impact on electrical grids and the causes and costs of power outages. Chapter 2, Fundamentals of Standalone Photovoltaic Systems, presents the principles, types, and components of standalone PV systems including solar sources, PV cells, PV modules, PV arrays, inverters, charge controllers, and types of storage batteries as well as the design of standalone systems, sizing methodologies, and details of modeling software for performance analysis and simulation of PV systems. Chapter 3, Mobile Photovoltaic Systems for Disaster Relief and Remote Areas, Chapter 4, Portable Standalone PV Systems for Disaster Relief and Remote Areas, and Chapter 5, Fixed Standalone PV Systems for Disaster Relief and Remote Areas, discusses three standalone PV systems and their benefits, methods of deployment, examples of practical systems and case studies related to appropriate topics for each chapter. The case studies include review and detailed analysis of select PV systems that can be applied for disaster relief and remote areas. Chapter 6, PV Systems Affordability, Community Solar, and Solar Microgrids, is related to affordable PV systems, community solar, and solar micro-grids. This chapter discusses new initiatives and programs for providing solar-generated electricity to low-income people both in the United States and the developing world at low cost as well as the ways of making the electric grid more resilience to outages. Chapter 6 also discusses two case studies about solar micro-grids in the United States and India.

Chapter 7, Solar Thermal Electricity and Solar Insolation, is divided in two parts. The first part is on the working principles and types of concentrated solar power technologies used in the United States and the rest of the world. The second part describes solar insolation/radiation, and the methods of measuring them using ground measurement and satellite images. It also provides a list of online databases for estimation of solar insolation/radiation.

The book also has a comprehensive appendix on the following topics:

- Building dye-sensitized solar cells
- Assembling one's own PV module
- Results of solar insolation/radiation using different databases
- Standards for PV systems.

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