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Off Grid Solar

A Handbook for Photovoltaics with Lead-Acid or Lithium-Ion Batteries

Off Grid Solar is a pocket guide and quick reference for anyone looking to build an electrical energy system with the free sunshine available to us all.

“The limitations to widespread solar are not centered on the cost, the efficiency, or the need for advancements in technology. The limitations are solely due to the lack of widespread knowledge on the subject.”

With that philosophy at heart, solar and battery expert Joseph P. O'Connor draws from his years of experience to craft a how-to guide needed by everyone around the world. Founder of OCON Energy Consulting, O'Connor has conducted and taught the installation/maintenance of Off Grid solar projects to people and communities as far away as the central African rainforest and right in his own backyard of Oakland, California. For anyone interested in harvesting their own solar energy completely detached from the grid, this is the book for you.

Thanks to straightforward explanations for readers of all levels, this book establishes a familiarity with the basic low cost components alongside the most innovative technologies. With this knowledge the reader can make better decisions based on their technology needs, rather than simply trusting the recommendations from others.

Need to keep costs down? How many solar panels are needed to refill the batteries? What is the best way to angle your solar panels? On projects both big and small, Joe's got you covered.

About the Author

Joe O'Connor is a solar manufacturing entrepreneur as well as a consultant, speaker, and writer on solar energy. Joe



has built off grid solar energy systems in the U.S., Haiti, Nepal, Portugal, Guatemala, and most recently in Virunga National Park, Democratic Republic of

the Congo. To learn more about his work in Congo, click here to read [*SolarCity, Tesla, and Virunga, Building Solar Micro Grids for the guardians of Africa's oldest and most biodiverse national park.*](#)

Seeking to amplify his impact after over a decade of traveling to remote places to install solar, Joe decided to share his knowledge and experience of off grid solar energy systems by writing a book.

Joe is currently a Senior Applications Engineer for Energy Storage at [Mercedes-Benz Energy](#). In his previous position at SolarCity, Joe supported the Micro Grid Team and the [GivePower Foundation](#) by designing solar photovoltaic and Tesla Powerwall systems. He also prototyped, designed, and patented a new solar racking system that enabled SolarCity to become one of the largest commercial installers in the U.S.

Prior to his work at SolarCity, Joe launched a cost-efficient solar racking product at solar manufacturing start-up, Sollega. Joe has also worked with Sustainable Energy Partners in San Francisco, completing dozens of renewable energy and energy efficiency projects.

Joe earned his M.S. from NYU Polytechnic University in Manufacturing Engineering and was selected as a recipient of the Catherine B. Reynolds Foundation Fellowship for Social Entrepreneurship. He earned his B.S. from Cal Poly University in Industrial Technology.

He first became passionate about renewable energy after volunteering with [GRID Alternatives](#)—the Habitat for Humanities of the solar industry—when he teamed up with other volunteers to install solar electric systems on homes of low-income families in the San Francisco Bay Area.

Joe believes that advancements in the renewable energy industry will help our global society break its dependency on oil, coal, and natural gas. He is on a mission to make renewable energy the dominant energy source on our planet.



The Market

One-quarter of the world’s population lack electricity and solar is proving to be the resource to power them. As of 2014, there were over 8.7 million expatriate living abroad and many choose to live off the grid. Even in the US there are 180,000 households living off the grid.

This book is written for anyone living off the grid, whether they plan to install solar, already own a system, or plan to hire an installation company. Also, this book explores strategies for all off grid locations around the globe, such as hot humid climates near the equator and for cold climates with minimal sunlight during the winter. Whether on a remote island of the Pacific Ocean, up in the hills of the Himalayas, or deep in the jungles of the Amazon, this book is relevant and acknowledges all the particular characteristics from anywhere in the world.

Figure 82: Baseline forecast off-grid solar users (million households)

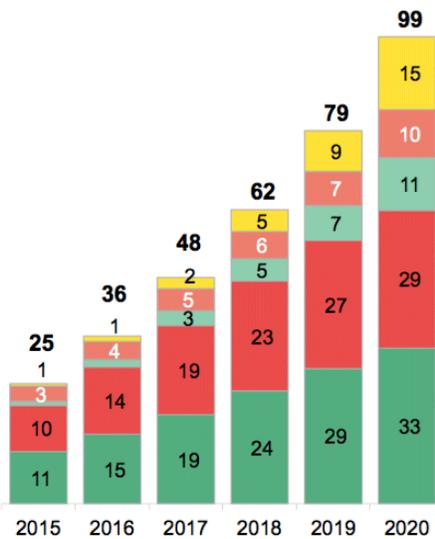
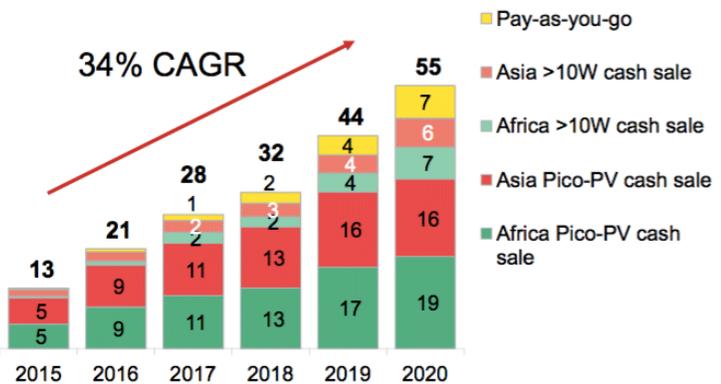


Figure 83: Baseline forecast annual sales (million units)



Source: Bloomberg New Energy Finance. Note: sales through third-parties with consumer-finance offerings are captured in cash sales. Sales projections assume product lifetime of three years and an increasing share of households to purchase a second device after one year. Unit sales assume sales of high-quality product. Unit numbers could be 2-4 times higher if the market shifts towards low-cost products with shorter useful lives and faster replacement cycles. The forecasts assume that 60-90 percent of households with a per capita income of \$2-10/day will purchase a >10W system by 2020, whereas only 10-15 percent of poorer households will do so.

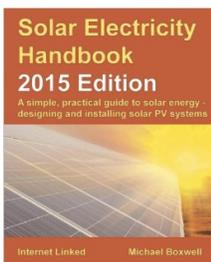
O’Connor states, “During my travels around the world, I have met many electricians who crave knowledge and resources so they can build better solar energy systems. Most of the systems I’ve visited in developing countries have an ad-hoc approach and the equipment is not matched properly, it’s missing safety equipment, and they malfunction quickly.”

Comparable Books

Most of the available Off Grid solar books focus either on the general needs of off grid living in rural America, or solar PV for grid-tied or off grid applications. These Off Grid focused books cover many topics including energy production, energy efficiency, gardening, and lifestyle changes, and many are specific to the North American climate and resources. The books focusing on solar PV treat off grid solar as a secondary topic and generally confuse the reader.

This is the first book of it's kind to focus on:

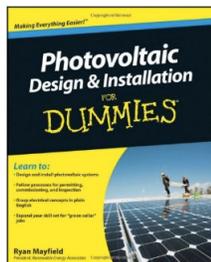
1. Off Grid only, eliminating the confusion of grid-tied systems
2. Upcoming technologies, such as Lithium-Ion batteries
3. Worldwide audiences, using internationally recognized standards



Solar Electricity Handbook

2015 Edition, is a simple, practical guide to using electric solar panels and designing and installing photovoltaic PV systems.

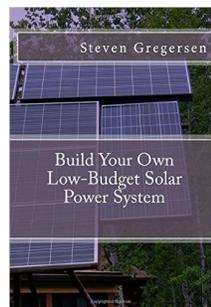
- \$19 on Amazon.com
- Author: Michael Boxwell
- **Amazon Best Sellers Rank:**
 - #1 Best Sellers in **Solar Energy Books**
 - #25,318 in Books
 - Approx. 9 books per day



Photovoltaic Design and Installation For Dummies

The fun and easy way to get a grip on photovoltaic design and installation

- \$17 on Amazon.com
- Author: Ryan Mayfield
- **Amazon Best Sellers Rank:**
 - #3 Best Sellers in **Solar Energy Books**
 - #41,880 in Books
 - Approx. 5 books per day



Build Your Own Low-Budget Solar Power System

This book is designed to address the concerns of those whose only desire is to build a simple, small-scale solar energy system but don't know where to start (or end!).

- \$12 on Amazon.com
- Author: Steven Gregersen
- **Amazon Best Sellers Rank:**
 - #52,011 in Books
 - Approx. 3 books per day

Chapters

Preface

- About the Author
- Disclaimer
- More Resources
- Acknowledgements

Introduction

- Why Solar?
- How Off Grid Solar Works

Site Design

- Start With Energy Efficiency
- Load Calculation Table
- Site Location
- Array Design
- Design for Your Load Pattern
- Design for a DC or AC System?

Battery Selection

- Lead-Acid Batteries
- Lithium-Ion Batteries
- Battery Type Considerations

Photovoltaic Module Selection

- PV Fundamentals
- Solar Module Specifications
- The Effects of Module Shading
- Strings of Modules
- The Effects of Temperature

Charge Controller Selection

- PWM or MPPT?
- Matching to Battery Type
- System Protection

Inverter Selection

- Inverter Fundamentals
- Pure Sine Wave vs. Modified Wave
- Single Phase, Split Phase & 3 Phase
- Passively-Cooled Versus Fan-Cooled
- Balance of System Selection

Wire Selection

- Overcurrent Protection Devices
- Combiner Boxes & Disconnects
- Grounding
- Lightning Protection

PV Mounting Selection

- Racking Types
- Mounting the Modules
- Hardware Considerations
- Wire Management

Electrical Enclosure Selection

- NEMA Enclosure Types
- Low Cost Enclosures

Secondary Power Selection

- Generator
- Wind & Hydroelectric Power

Design Considerations

- Minimum Design Conditions
- Generating Capacity vs. Storage Capacity

System Design

- System Sizing
- Line Diagrams
- Installation Safety
- Tools

Operations & Maintenance

- Battery Maintenance
- Inverter & Charge Controller Maintenance
- Module & Racking Maintenance

Understanding Electricity

- Power vs. Energy
- Voltage & Volts
- Current & Amperes
- Resistance
- Ohm's Law

More Resources