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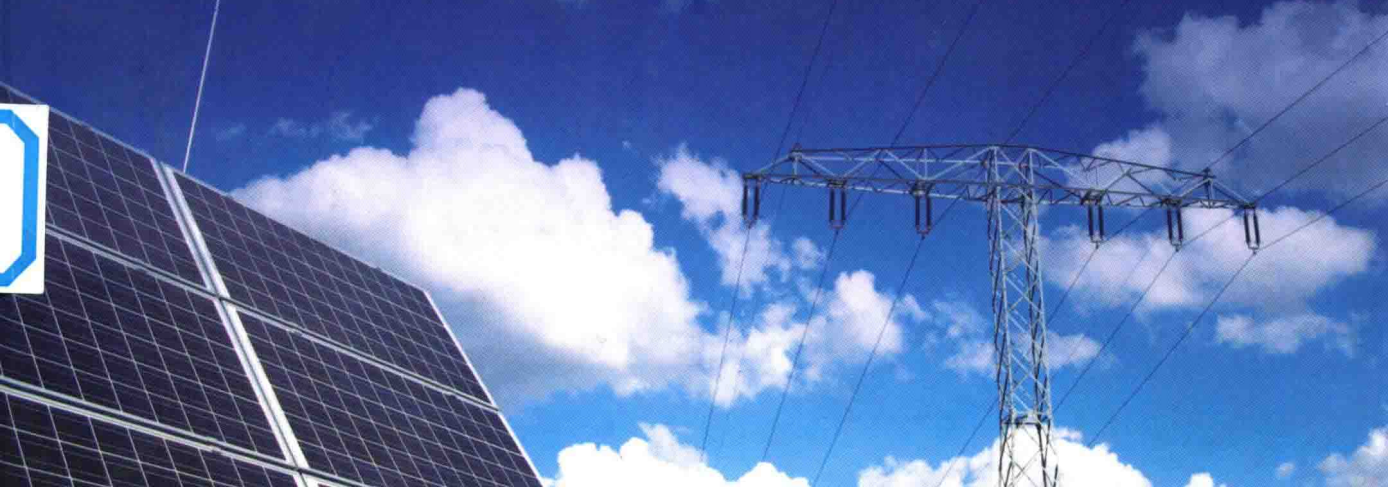
GRID-CONNECTED SOLAR ELECTRIC SYSTEMS

THE EARTHSCAN EXPERT HANDBOOK FOR PLANNING, DESIGN AND INSTALLATION

Geoff Stapleton
and Susan Neill



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Grid-connected Solar Electric Systems

Solar electricity – or photovoltaics (PV) – is the world's fastest growing energy technology. It can be used on a wide variety of scales, from single dwellings to utility-scale solar farms providing power for whole communities. It can be integrated into existing electricity grids with relative simplicity, meaning that in times of low solar energy, users can continue to draw power from the grid, while power can be fed or sold back into the grid at a profit when their electricity generation exceeds the amount they are using.

The falling price of the equipment combined with various incentive schemes around the world has made PV into a lucrative low carbon investment, and as such demand has never been higher for the technology, and for people with the expertise to design and install systems.

This Expert handbook provides a clear introduction to solar radiation, before proceeding to cover:

- electrical basics and PV cells and modules
- inverters
- design of grid-connected PV systems
- system installation and commissioning
- maintenance and troubleshooting
- health and safety
- economics and marketing.

Highly illustrated in full colour throughout, this is the ideal guide for electricians, builders and architects, housing and property developers, home owners and DIY enthusiasts, and anyone who needs a clear introduction to grid-connected solar electric technology.

Geoff Stapleton has been instrumental in developing training and capacity building both in Australia and overseas, particularly in Ghana, Sri Lanka, Malaysia and China. He set up Global Sustainable Energy Solutions Pty Ltd as a renewable energy training and consultancy business in 1998 and is a part-time lecturer at University of New South Wales, Australia.

Susan Neill has worked in the renewable energy industry for over 25 years. She is now director of training and engineering for Global Sustainable Energy Solutions and is a guest lecturer at UNSW, Australia.

Preface and Acknowledgements

The worldwide market for grid-connected solar electric systems has increased from 1.55 gigawatts (GW) installed in 2006 to 11.86GW in 2010. This 2010 figure represents an increase of 665 per cent over the 2006 figure.

It is to be expected that the general public as well as tradesmen, technicians and other professionals will need information about all aspects of grid-connected solar as they see these systems installed in their suburbs and on larger roof spaces; they will also wish to know how it affects their lives.

In the absence of basic technology and installation information, how and why grid-connected solar electric systems work and the value they can represent for the electricity grid may be misrepresented. As can be seen by the increase in the grid-connected solar electric market, the technology and production of solar modules and enabling products (e.g. inverters, mounting structures etc.) are now mature; product demand has been increasing from year to year with healthy forward projections, so many more manufacturers have moved into this technology market, driving prices down; governments around the world have introduced various economic drivers for renewable energy, with those affecting solar electric systems being typically subsidies, feed-in tariffs and redeemable renewable energy credits.

Global Sustainable Energy Solutions was pleased to be approached by Earthscan to write this book now, because the market demand for the product clearly demonstrates a need for information at all levels.

This book is suitable for anyone wanting to learn about grid-connected solar electric systems starting with the explanation of solar radiation, its origin, solar modules, solar electric systems, system composition, system installation, through to the economics of these systems.

Thanks are due to a number of people who have contributed time and/or information during the evolution of this book: Caitlin Trethewy, who has worked from day one on this publication collecting information, researching, writing content and progressively editing the chapters to completion; the staff at Global Sustainable Energy Solutions Pty Ltd who have contributed to the book's development; Pamela Silva for her contribution while in Australia from the US; Anthony Allen for his technical drawing skills; all image providers, whom we trust are correctly acknowledged; the companies and individuals who have provided us with case study information and photos as follows: Blair Reynolds, BMC Solar (www.bmcsolar.com), Briana Green and Green Solar Group (www.greensolargroup.com.au), Frank Jackson, Paul Barwell, Tony J. Almond and Planet Energy Solutions (www.planetenergy.co.uk).

Acronyms and Abbreviations

AC	alternating current
ANU	Australian National University
ASCE	American Society of Civil Engineers
BIPV	building-integrated photovoltaics
BCSC	buried contact solar cells
BoS	balance of system
CCC	current-carrying capacity
CdTe	cadmium telluride
CIGS	copper-indium-gallium-diselenide
CSI	California Solar Initiative
CSP	concentrated solar power
CVD	chemical vapour deposition
DC	direct current
DNO	distribution network operator
ELV	extra low voltage
ESTI	European Solar Test Installation
FiT	feed-in tariff
GHG	greenhouse gas
GSES	Global Sustainable Energy Solutions
HSE	health, safety and environment
HIT	heterojunction with intrinsic thin layer
IEC	International Electrotechnical Commission
IEEE	Institute for Electrical and Electronics Engineers
I_{mp}	current at maximum power point
IP	ingress protection
IREC	Interstate Renewable Energy Council
I_{sc}	short-circuit current
LED	light-emitting diode
LV	low voltage
MCB	miniature circuit breaker
MOV	metal oxide varistor
MPPT	maximum power point tracker
NABCEP	North American Board of Certified Energy Practitioners
NEC	National Electric Code
NEG	net excess generation
NEMA	National Electrical Manufacturers Association
NOCT	nominal operating cell temperature
NREL	National Renewable Energy Laboratory
P_{max}/P_{mp}/MPP	maximum power point
PSH	peak sun hours
PV	photovoltaic
PVGIS	Photovoltaic Geographical Information System
RECs	renewable energy certificates
RHI	Renewable Heat Incentive

ROCs	Renewable Obligation Certificates
RPS	renewable portfolio standard
SDI	single core, double insulated (cable)
SRECs	Solar Renewable Energy Credits
STC	standard test conditions
TRECs	Tradable Renewable Energy Certificates
UEDS	utility external disconnect switch
UL	Underwriters' Laboratory
V_{mp}	voltage at maximum power point
V_{oc}	open-circuit voltage
Wh	watt-hour
Wp	watt-peak

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