Wind Power

The twin threats of climate change caused by burning fossil fuels and escalating fossil fuel prices make the further rapid development of renewable energy sources a global imperative. Energy provided by the power in the winds is destined to become ever more important. Though no panacea, wind power has the potential to make a substantial contribution to meeting electricity needs in many countries. This concise and accessible account of the history and future development of wind power technology will appeal to a wide audience of engineers, scientists, policymakers and students, and anyone interested in learning more about the potential of wind power.

Wind power has been used increasingly to generate electricity since the early 1990s in Europe, the United States and elsewhere, and the global installed wind power capacity has been doubling every three to four years. It is now making the transition from being a minor contributor to becoming an important source of electricity. However, the level of understanding of what can be expected from wind systems in the future – and at what cost – is generally poor. This book requires no prior technical knowledge, and describes the development of wind power technology from medieval times to the present. It looks forward to the important role that wind power is expected to play – as a clean, competitive and abundant energy source – in helping to meet our future energy needs.

- Considers the factors underpinning wind power's exponential growth since 1990, to help understand what we can expect from wind power in the future.
- Shows how the cost of wind energy compares with electricity produced by burning fossil fuels.
- Explains simply how wind turbines (and windmills) work.
- Explains why wind power's intermittency does not prevent its large-scale use.

PETER MUSGROVE's wind power interests go back to 1974 when he was teaching engineering at the University of Reading. Though wind power was then the UK's least favoured renewable energy option he strongly argued the case for large offshore wind farms and gained recognition for their potential. He was also very much involved in the UK vertical axis wind turbine programme through the 1970s and 1980s. He was one of the prime movers in the 1978 formation of the British Wind Energy Association (BWEA) and was its first Chairman. He left academia for industry in 1988 and as National Wind Power's Head of Development through the 1990s was involved in all aspects of wind farm development and wind turbine assessment. He retired in 2003 and was given the BWEA's first Lifetime Achievement Award.

Wind Power

PETER MUSGROVE

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi, Dubai, Tokyo

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521762380

First published 2010

Printed in the United Kingdom at the University Press, Cambridge

A catalogue record for this publication is available from the British Library

ISBN 978-0-521-76238-0 Hardback
ISBN 978-0-521-74763-9 Paperback

For my grandchildren
James, Terry, Faith, Jonathan and Euan
and their generation

Contents

Preface

The high standard of living that we in developed countries enjoy is underpinned by the massive consumption of oil, gas and coal, the so-called fossil fuels. However we now recognise that the carbon dioxide emissions caused by the combustion of these fuels is changing the global climate, with potentially devastating consequences for us all. Electricity generation is the largest single source of carbon dioxide emissions, and the need to move to the production of electricity in ways that avoid these emissions has stimulated an upsurge of interest in renewable sources of energy.

Wind power is the renewables technology that has made most progress in recent years. And though modern wind turbines have much in common with traditional windmills they are very much larger and much more efficient. Since 1973, when the first oil crisis encouraged a number of countries to commence their development, wind turbines have progressed to the point where they can generate electricity at a cost that is comparable with that produced by burning fossil fuels, though without the carbon dioxide emissions and price volatility. In 2008 the global installed wind power capacity passed 100 000 MW and wind power provided just over 1% of global electricity; by 2020 the installed capacity is likely to exceed 1 million MW, with wind power providing about 10% of global electricity, a percentage that is expected to grow steadily in the following decades.

This book tells the story of the development of wind power technology from its medieval beginnings through many centuries of success to its nineteenth-century decline and its late-twentieth-century revival, and looks forward to the important role that wind power seems likely to play – as a clean, competitive, reliable and abundant energy source – in helping to meet twenty-first-century energy needs. The core text of Chapters 1 to 9 requires no prior technical knowledge – just a reasonably numerate interest in how we can meet our future energy needs without causing further damage to the climate. The appendices and extensive notes give more detail for those who require it.

Acknowledgements

My interest in wind power began in 1974 when I was a Lecturer in the Engineering Department at the University of Reading and I am grateful to all my colleagues there, and in particular to Peter Dunn who was then Head of the Department, for their encouragement and support.

In 1988 I left academia to go into industry and I would like to thank David Lindley, then Managing Director of the Wind Energy Group, for inviting me to join him at WEG and for his support in facilitating my transition. I moved as Head of Development to National Wind Power (NWP), a related wind farm development company, when it was formed in 1991 and remained there until my retirement in 2003. I am very happy to acknowledge the debt that I owe to my many former NWP colleagues for all that I learnt from them, and though I cannot name them all – the list would be too long – I particularly wish to express my thanks to Alan Moore, Pam McEvoy and John Warren for their friendship, encouragement and support.

I have learnt from, and enjoyed the company of, many who have contributed to the global development of wind power. Again space does not allow me to name them all but I would particularly like to thank Henrik Stiesdal for his friendship over many years, and for the many technical discussions which greatly improved my understanding of wind turbine technology; I am happy also to take this opportunity to express my appreciation to him for reading my draft of Chapters 4, 5 and 6, and for making many constructive suggestions.

Last, but certainly not least, I wish to express my thanks and gratitude to my wife Sonja for her patience and support over many years, and in particular through the past four years when 'the book' has taken priority over a host of other potential retirement activities.