

Smart Grid: Integrating Renewable, Distributed and Efficient Energy edited by Fereidoon P. Sioshansi (Elsevier Academic Press: Waltham MA 2012) 568 pages, ISBN 978-0-12-386452-9 hardback. List price \$99.95.

Smart grids may represent the future of the electricity sector – bringing it “into the information age” as the preface to this book puts it – but it is often unclear what the term means, much less what changes are involved and what are the implications over the longer term. So this edited volume is very welcome. Its authors include both academic commentators and industry participants from half a dozen countries, who look at the smart grid in its various manifestations and from various points of view. In doing so the authors make clear that while there will be major opportunities, there are also major obstacles. The vision will not be achieved in the same way or at the same pace in all countries. Nonetheless, much the same underlying challenges are being faced everywhere – updating electricity grids for the liberalised market and for the new imperatives of integrating intermittent renewable and distributed generating sources and enabling more effective demand-side participation. It is clear that the future electricity system will be very different from the model familiar throughout the 20th century and that a better understanding of the likely changes is needed.

The volume starts with a substantial introduction from the editor, Fereidoon Sioshansi of Menlo Economics, who makes the first of many attempts to define what exactly the smart grid is and (perhaps more helpfully) what it will do. The ultimate goal is, more or less, to turn the industry on its head “from a historically one-way conduit that delivers electrons from large central stations to load centers, to a two-way, intelligent conduit, allowing power flows in different directions, at different times, from different sources to different sinks”. Sioshansi introduces some of the main topics covered in more detail elsewhere – will customers buy the idea? are the benefits worth the costs and risks? – and provides an overview of the various individual chapters. He also contributes a short epilogue underlining the uncertainties which still remain about the goal and its realisation.

The book is organised into four main sections:

- The overall context
- The growing role of renewable and distributed generation
- Smart infrastructure, smart prices and smart devices
- Case studies and pilot projects.

In Chapter 1 of the volume, Steve Hauser of the US National Renewable Energy Laboratory and Kelly Crandall, who is working with the city of Boulder Colorado on a smart grid project, emphasise what will be one of the main themes of the collection – that smart grid is a lot more than just “technology”. They list four main criteria for a smart grid – that it should be affordable, clean, reliable and capable of supporting the evolving economy of the 21st century and discuss the changes taking place worldwide against this background. They argue that changes to date have largely been driven by engineers and technologists – a much wider constituency will have to be engaged if the full potential of the smart grid is to be realised.

Chapter 2, by Stephen Healy and Iain MacGill of the University of New South Wales, argues that the supply side orientation of the electricity sector will have to change – the future will involve “smart users” as well as smart technologies and this will change the whole relationship between the industry and its customers.

In Chapter 3 Ahmad Faruqi of the Brattle Group looks at one particular aspect of this relationship – the ethics of dynamic pricing. He argues that flat rate pricing, with the cross-subsidies between different groups of consumers that it implies, is unfair and that dynamic pricing will both be more ethical and more efficient. Nonetheless, there are many barriers to achieving this – not least that customers tend to see dynamic pricing as itself unfair – and consumer engagement will be vital.

Chapter 4 by Frank Felder of Rutgers University also looks at the equity implications of smart grid. The estimated costs are very high – between \$300 and \$500 billion over a twenty year period in the US for instance. While the estimated benefits are two to four times as great, the changes will obviously have significant distributional consequences and Felder argues that regulators will need to give them careful consideration.

Chapter 5 introduces the second part of the book, which focuses on the supply side. In it, Jianhui Wang of the Argonne National Laboratory along with Maria Wang and Dan Ton, who have been engaged with the USDOE’s smart grid programme, look at the integration of renewables and such issues as resource intermittency, capacity firming and energy storage; the challenges are significant and there is no single answer – both renewable generation and storage options come in a variety of different forms and the best fit between them will depend on the particular circumstances.

In Chapter 6, Heather Sanders, Lorenzo Kristov and Mark Rothleder of California’s Independent System Operator look at the Californian roadmap and the challenges it will involve, including the increasing magnitude and frequency of congestion as renewable sources, which tend to be geographically concentrated, are connected up to the grid. Better forecasting and monitoring of grid conditions will be needed to maintain reliability.

In Chapter 7, William Lilley, Jennifer Hayward and Luke Reedman of CSIRO in Australia look at the integration of renewable and distributed generation on the basis of a modelling approach. They conclude that significant savings are possible in meeting the combined challenges of reducing emissions while maintaining security.

Chapter 8, by Glenn Platt, Adam Berry and David Cornforth of CSIRO, looks at the role of microgrids, which may facilitate the transition to the intelligent and responsive electricity systems of the future. Microgrids raise a number of challenges but also offer significant benefits to the consumer and the authors conclude that they will be a major stepping stone on the way toward smart grid development.

In Chapter 9, Theodore Hesser of Bloomberg and Samir Succar of the NRDC look at one particular aspect of renewables integration – direct load control and demand response. They point to the asymmetry of wind and load ramps which make “spilled” energy more likely than a need for additional capacity. Thus demand response may well be as much about increases as curtailments of demand and they point to a set of loads which might be suitable for this purpose.

Chapter 10, by Philip Hanser, Kamen Madjarov Warren Katzenstein and Judy Chang, all currently or formerly with the Brattle Group, also look at wind integration via demand response. They discuss a number of US programmes in this area and argue that there are significant potential benefits – for consumers, generators and the environment (in the form of reduced emissions). They conclude that demand response is a “perfect complement” to the greater penetration of wind energy.

Chapter 11 starts the third section, on infrastructure and prices, and in it Chris King of eMeter and James Strapp of IBM discuss software infrastructure and IT challenges for smart grid development. They argue that this is the biggest potential risk area – more so than meters, communications or even installation issues. Case studies are described showing how the obstacles can be overcome and benefits realised.

Chapter 12, by Stephen Braithwait and Daniel Hansen of Christensen Associates, looks at the response to dynamic pricing by large industrial and commercial customers, drawing on the California experience, in particular of critical peak pricing. The studies confirm that there can be a significant customer response when prices rise substantially on a limited number of critical days, though it tends to be concentrated in a small number of participating entities.

In Chapter 13, Christine Brandstatt, Gert Brunekreeft and Nele Friedrichsen from the Bremer Energie Institut consider the German experience of smart pricing to reduce network investment. Different European countries have different approaches to transmission pricing and connection cost contributions, often constrained by regulatory requirements. The authors suggest that more flexibility would be desirable and that regulators need to think more carefully about network investment incentives.

Chapter 14, by William Prindle and Michael Koszalka of ICF, looks at how to make smart grid deployment more successful in terms of customer acceptance and regulatory approval. They examine a number of case studies to see how customer benefits can be more effectively explained and delivered. A key message is that benefits should be demonstrated before utilities seek to recover costs.

In Chapter 15 Patti Harper-Slaboszewicz of CSC and Todd McGregor and Steve Sunderhauf of Pepco Holdings also consider the customer view. They list a range of customer applications in the area of home automation, generally of the “set and forget” variety designed to make customer involvement simpler and more convenient.

Chapter 16 by Bruce Hamilton of Adica, Chris Thomas of CUB and Se Jin Park and Jeong-Gon Choi of the Korea Power Exchange look at customer experiences, in particular of in-home energy display devices and smart appliances which automatically respond to price signals. Although they find it difficult to forecast the pace of development they stress that to maximise the potential of smart meter investments, you have to go beyond the meter.

The final section looks at case studies. Chapter 17, by Susan Covino, Peter Langbein and Paul Sotkiewicz looks at PJM’s experience of demand response (DR). DR can participate in capacity, energy and ancillary service markets; at present, the main value is realised in capacity markets but the authors see DR developing into a wider form of price responsive demand. They look forward to synergies between smart grid investments and demand response programmes.

Chapter 18 by Magnus Hindsberger of the Australian Market Operator, John Boys of Auckland University and Graeme Ancell of Transpower examine the integration of electric vehicles and wind power in New Zealand. While the country undoubtedly displays special features, the authors show how dynamic demand control can reduce the costs of both increasing wind power penetration and the growing numbers of electric vehicles expected in future systems.

Finally chapter 19, by six researchers at Mines-ParisTech looks at the impact of smart electric vehicles on day ahead prices in the French market by modelling the effect on various demand and recharging scenarios. The results are complex – peak prices can actually fall in some situations as power is drawn by the system from vehicle batteries; conversely prices increase in off-peak hours as batteries are recharged. Given the many other changes under way the authors worry that the market may have difficulty adapting.

Overall the study is extremely useful and timely, providing a wide-ranging overview of many of the issues associated with smart meters. However, it does not entirely avoid the pitfalls common to compilations of this sort. On the one hand, there is quite a bit of repetition (definitions of smart grid and explanations of the problems of intermittency, for instance); on the other hand, the volume is far from comprehensive. The geographical coverage is somewhat limited and the main focus is on the US, and to a lesser extent Australia. There is virtually nothing, for instance, about the UK or, more significantly, Asia in general and developing Asia in particular. China is currently showing a great deal of interest in smart grids and it would have been helpful to know what differences of approach there are there. A number of individual subjects also receive scant coverage. Cyber-security gets only passing mention and another current topic, electromagnetic pulse attack, appears not to be covered at all, though one would like to know whether smart grids increase or reduce vulnerability. Privacy and safety issues are also barely addressed, perhaps because they are more of a concern in Europe than the US.

Despite these gaps the book can be warmly recommended. Smart grids are only just starting to develop and the longer term implications are still unclear. Nonetheless they will undoubtedly be at the heart of future power systems, and these may well be completely unrecognisable in 20th century terms. Getting a better understanding of these fundamental changes is vital for all concerned with the future of the industry or the transition to a low carbon society, and this volume provides an valuable introduction.