BOOK REVIEWS

Smart Grid: Integrating Renewable, Distributed and Efficient Energy edited by FEREIDOON P. SIOSHANSI (Waltham MA: Elsevier Academic Press, 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, many 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 much 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 Faruqui 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 20-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 micro-grids, which may facilitate the transition to the intelligent and responsive electricity systems of the future. Micro-grids 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 health 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 a valuable introduction.

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Energy Conservation in East Asia: Towards Greater Energy Security, edited by Elspeth Thompson, Youngho Chang and Jae-Seung Lee (Singapore: World Scientific Publishing, 2011) 408 pages, ISBN 13-978-981-277-177-3

Given the tremendous potential for continued growth of energy use in South East Asia, the topic of energy efficiency—and energy security—is critically important to anyone interested in the future of energy, climate change and energy security. Viewed in this context, the volume titled *Energy Conservation in East Asia: Towards Greater Energy Security* and edited by E. Thompson, Y. Chang & J-S Lee is timely and topical.

This edited volume covers energy supply and demand in ASEAN + 3 countries, which includes China, Japan and South Korea. Cambodia, Laos and Myanmar are mostly excluded since they currently consume relatively little commercial energy—and also due to the paucity of reliable energy-related data.

In the introductory chapters of the book, the editors point out the sheer scope of the project covering such a vast region compromised of so many countries in different stages of development and economic maturity. It is a near impossible task to even try to cover so much in a single volume.

Aside from differences in size and population—say Brunei or Singapore on the one end and China, Japan and Korea on the other—there are other vast differences in the level of development, economic maturity, climate and so on. This is further compounded by the fact that some countries are major exporters of energy—e.g., Indonesia—while others are net importers, some with virtually no indigenous fossil resources—e.g., Japan and Korea. Add to the complexity vast energy price disparities among the countries, some of which continue to subsidize various fuels while others tax it, notably in petroleum products. Elec-

tricity prices are, likewise, vastly different due to government policies, tariff rigidities and subsidies.

With respect to energy efficiency and conservation, the editors point out that in many countries, current average per capita consumption is negligible by standards of the OECD countries, making marketing energy efficiency a nonstarter. Moreover, limited government budgets and human resources mean that in many cases, there is virtually little or no energy efficiency programs beyond a superficial policy goal or target. How can it be otherwise in countries like the Philippines, when many rural communities use little "commercial" energy other than in transportation fuels? How can governments encourage more efficient appliances or lighting in places where consumers can barely afford the least efficient appliances? Or for consumers who don't even have reliable access to electricity?

The book's first chapter by Youngho Chang and Elspeth Thompson provides an overview of energy supply and demand in the region, including projections to 2020. While this provides a useful context for the following chapters of the book, it suffers from two serious deficiencies.

First, the horizon for examining future trends and projections ends in 2020—which is an inadequate horizon to examine the effect of introducing alternative energy, pricing or energy conservation policies and see the impact of these policies. The existing infrastructure, power plants, cars, pipelines, factories, buildings, etc. will most likely be largely intact given the slow pace of change by 2020.

Second, in the appendix to Chapter 1, where projections of energy demand to 2020 are presented, only a limited—and rather arbitrary—number of scenarios are examined. For each country, the historical trend, last year's trend and two alternatives assuming growth at 5% and 10% are shown. The same projections appear to be applied to all countries regardless of their current stage of development or economic or population growth prospects. While a country like Vietnam may in fact experience 5-10% growth rate to 2020, this would not apply to Japan or South Korea, whose economies are far more mature and prospects for growth less robust.

In chapter 2, the same two contributors, examine the potential for energy conservation in the region by examining energy intensity trends, income elasticity of demand and their interdependence.

Particular attention is given to transportation fuels, a major contributor to future demand growth across the region, but particularly in the fast growing economies of China, Indonesia, Malaysia, Thailand and Vietnam. For example, many of the less-affluent countries in the region import vast numbers of old, fuel-inefficient and polluting cars, buses and trucks from the more affluent countries, notably Singapore and Japan. In Singapore, for example, cars older than 10-years cannot be operated, which means a thriving market for export of older models. This practice is clearly good for Singapore or Japan, but not for importing countries that end up with the inefficient hand-me downs.

The chapter concludes that, ". . . there is tremendous potential for energy conservation," but fails to show how big the potential scope of the savings may

be or the specific measures that could enhance the scope of the savings—except for rather dated 2005 predictions from the International Energy Agency (IEA), primarily focused on oil.

In chapter 3, Yasuo Tanabe discusses energy collaborative opportunities in the region and makes comparisons to the experience of the OECD countries and the IEA. The discussion leaves much ground unexplored and many stones unturned. It concludes that "energy policy cooperation should be based on the central principles of consumer status, self-determination and market function," vague enough to mean anything. The chapter mentions the need for increased attention to "demand side", "a diversified energy mix" and "oil security," good advice but not specific to be helpful.

The chapter fails to examine the growing competition, tensions and regional rivalries among the regional economies, especially as China's increasing appetite for energy puts it on a virtual collision course with Japan and Korea, its much smaller neighbors who are nearly entirely dependent on imported energy for their economic survival. Other nuances of regional rivalries, cooperation and competition are not explored.

The balance of the book is devoted to an examination of individual countries—in alphabetical order starting from Brunei and ending with Vietnam. The coverage is roughly even in terms of the number of pages devoted to each country—which poses a problem. Brunei, with a population of 383,000 (in 2006), for example, is covered in 24 pages, while China, with a population of 1.2 billion is covered in 17 pages. This imbalance is striking.

The other deficiency in country-specific chapters is the difference in style, format and level of detail and uneven coverage of topics. It is problem common to edited volumes, which could have been better addressed by requiring a standard format and style for each country with a provision to allocate more attention to the large regional giants, China, Japan and Korea, in that order.

Despite these deficiencies, the volume provides a starting point for anyone interested in an overview of the ASEAN region's energy status and future prospects. Viewed from this perspective, the editors and the contributing authors provide the basics that researchers and scholars can build on. The topic is timely and topical, deserving further study.

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The Future of Electricity Demand: Customers, Citizens and Loads, edited by Tooraj Jamasb and Michael G. Pollitt, (Cambridge: Cambridge University Press, 2011) 506 pages. Hardback. ISBN 9781107008502

This is the third book arising from the Supergen Networks consortium, a long-running collaboration between engineers, economists and social psychol-

ogists funded by the UK Research Councils. I should declare an interest: I have been a member of the current consortium (Supergen Flexnet) and its predecessor (Futurenet) since they started work in 2003, but I was not involved in the work package (known as "Customers, Citizens and Loads") that produced this book (with a number of contributions from non-members of the consortium). The first book concentrated on technologies; the second on policy and generation and this book focuses strongly on the demand side.

Flexnet was adopted as the consortium's name because of the perceived importance of creating a more flexible network in the face of a very uncertain future, and one of the first chapters, by Ault, Frame and Hughes, describes four scenarios for electricity demand in 2050 that demonstrate the range of uncertainty. Electricity demand in 2050 might be 10% below its level in 2000, or 30% above it; in one scenario, almost one-quarter of electricity is generated by micro combined heat and power or micro-scale renewables, which contribute practically nothing in another. Electricity demand rises relative to the overall demand for energy, which falls in three of the four scenarios. Reading this chapter just after that by Platchkov and Pollitt, which sets out the fundamental economics behind energy demand, made me wonder what the UK economy would look like if it achieved this reduction in demand. The demand for energy services rises with income and falls with price, while improvements in efficiency reduce the amount of energy needed to provide a given energy service (and hence its price). Unless efficiency improves dramatically, large reductions in demand by 2050 therefore point to higher prices (which Platchkov and Pollitt identify as the key to demand moderation). Would there come a point at which these prices had a significant effect on growth—particularly if other countries did not see the same price trend?

Regardless of their long-term trends, recent price rises have pushed many UK households into fuel poverty, a concept discussed by Waddams Price, who points out that moves to market-based pricing in the poorer countries hoping to join the European Union could lead to large increases in the number of households having to spend more than 10 per cent of their incomes on heating and lighting. Jamasb and Meier concentrate on the UK, showing the interaction between household characteristics and fuel poverty. They conclude on an optimistic note, hoping that smart meters may help the fuel-poor to shift their consumption to cheaper periods and access suppliers offering better prices.

Not surprisingly, the prospects and implications of smart metering to enable more demand-side participation are discussed in several other chapters. Brophy Haney, Jamasb and Pollitt describe what a smart meter can actually do, its likely cost and potential benefits, drawing on a range of international experiences. The operational savings (e.g. in meter-reading) to the utility are often too small to justify the cost of installing smart meters, but demand response facilitated by dynamic pricing could add significant value. Smart meters with dynamic prices would relax two of the constraints discussed by Torriti, Leach and Devine-Wright, but they stress the need to understand consumers' behaviours. This chapter contains a necessarily brief discussion of the diverse motivations for pro-environ-

mental behaviour (which should be taken into account when sending targeted messages) and a proposed financial incentive scheme for end-users. I hope the authors will follow up with a journal article that gives enough information to allow the scheme to be fully assessed. They refer to the company running the incentive scheme as "the utility", which implies (to me, in any case) that demand response would take place within a rather traditional business model. In contrast, Bouffard and eight co-authors describe an alternative market organisation, in which a consumer with an "energy box" to control her demand would contract with an aggregator which would feed her responses into the market.

Hong, Johnstone, Kim and Tuohy examine the technology for demand side control, as well as the drivers for it and the kinds of actions involved. Their best (but possibly unachievable) outcome would be one in which building occupants were unaware that their energy demands were being managed, because it would be done without compromising comfort or functionality levels. They describe a control algorithm which is applied (in a case study) to match the energy demand from a refrigerator to the output from a PV panel. The challenge of asking how great a contribution could be made by such algorithms is taken up by Silva, Stanojevic, Aunedi, Pudjianto and Strbac. They estimate the value of providing reserve by shifting the demand from washing machines, washer-dryers and dishwashers as the amount of wind generation on the British power system rises. This is around £5 per appliance per year with 30 GW of wind capacity (depending on how flexible the remaining generation mix is), but more than doubles with 40 GW of wind capacity. Dynamic demand from refrigerators and freezers that automatically postpone their consumption if the system frequency is low can be worth around £30 per fridge with 30 GW of wind capacity. These benefits (particularly for the fridges with high wind generation) exceed the cost of installing control equipment, but could not, on their own, justify the cost of smart meters.

The benefits of charging electric vehicles outside peak times give another motivation for smart metering. Marsden and Hess show that even with aggressive assumptions, the electrical energy for vehicles is unlikely to exceed 5% of total consumption by 2030; nonetheless, this could place significant burdens on local distribution networks if most consumers started to charge vehicles at the time of the early evening winter peak. Jamasb and Marantes outline the modelling approach used by one distribution network operator to forecast electricity demand and predict investment needs, which could be used to target areas for demand-side interventions.

Most demand side interventions, as surveyed by Brophy Haney, Jamasb, Platchkov and Pollitt, are attempts to reduce the overall level of energy demand. They show the benefits from having an integrated strategy that can address the various barriers to improving energy efficiency and take account of interactions between policy measures. Clarke, Hong, Johnstone, Kim and Tuohy discuss one area, policy towards building energy demand, showing that large reductions are possible when new buildings are compared to the UK average, particularly for space heating. This chapter contained the one production error I noticed—the

graphic for Figure 16.8 was repeated over a different title for Figure 16.9, while that over the title for Figure 16.10 seemed to be more compatible with its predecessor. Steinbuks also focused on overall energy demand in his survey of econometric studies of the factors driving this—as we get more experience of real-time energy pricing, I hope more evidence of its effects will be gathered and analysed.

Two chapters are centred on the degree of centralisation in our energy system. Kelly and Pollitt give examples from the UK and abroad of how local government can take a lead in areas such as combined heat and power, energy from waste, or creating Energy Service Companies. Watson and Devine-Wright argue that decentralised approaches can have advantages (and disadvantages) in the move to a low-carbon energy system, but point out that policy-makers may not appreciate how far the UK is currently locked in to a largely centralised system.

Policy-makers in a democracy must take account of public attitudes, of course, and Akcura, Brophy Haney, Jamasb and Reiner draw on two surveys conducted for the Electricity Policy Research Group at the University of Cambridge in 2006 and 2008 to show how these can change. In 2006, 46% of the sample prioritised either increasing the use of renewable energy or reducing the impacts of climate change, while 13% put keeping prices low as their top priority. In the later survey, with higher energy prices and recession looming, prices were the top concern for 41% of the sample, while only 17% prioritised the climate-related objectives. Anyone who thinks this is not a problem should read the chapter by Chong, Garnsey, Hill and Desobry on the UK's experience with daylight saving time. Moving the clocks forward by one hour would better align our activity with the hours of daylight, reducing energy demand, but it would be darker when those in the north of the UK went to work in winter. The UK experimented with daylight saving time from 1968 to 1971, but this was abandoned, in part at the behest of campaigners who stressed the higher road casualties from accidents on dark winter mornings. The fact that there was a larger reduction in casualties due to lighter winter evenings did not sway the public debate.

I have described one personal journey through the book; the editors have arranged the chapters in a different, and entirely logical, order that leads from economic fundamentals through technology and social dimensions to policy and regulation. The chapters form a coherent set, with a good coverage of the issues—this is perhaps not surprising when nearly half the individual chapters had one or both editors among their authors, including a useful introductory outline and some sensible concluding reflections. It shows the value of getting social scientists and engineers to collaborate in researching topics of mutual interest, and while the particular consortium which inspired this useful book is about to end, I hope that the links it engendered will long outlive it. If so, this book will be a worthy tribute to what collaborative research can achieve.

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