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Book Review, The Electric Battery: Charging Forward to a Low-Carbon Future

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Book Review

K.B. Jones, B.B. Jervey, M. Roche, S. Barnowski. *The Electric Battery: Charging Forward to a Low-Carbon Future*, Praeger (2017)

Storage technologies that receive electricity from the grid and store it for later use or release back to the grid, or for powering vehicles, are rapidly emerging as a jack of all trades in the electricity and transportation sectors. In the electric grid, storage has numerous applications behind the meter and throughout the generation, transmission and distribution systems. In addition, a storage system has unique flexibility to recoup value from multiple applications. Storage installations are cropping up at a record pace, electric vehicles are increasing in market share and pervasiveness, and companies such as Tesla are producing batteries on a large scale for residential consumers. Much excitement surrounding storage comes from its potential for ending the just in time nature of the electric grid, making consumers more (or completely) independent from utilities and helping facilitate the integration of increased renewable energy generation. As this book's title suggests, all of this could accelerate the ongoing transition to a low-carbon economy. Yet these rapid developments raise many legal, technological and policy issues that are only beginning to be addressed.

The Electric Battery is the product of a Vermont Law School team led by Kevin Jones, the school's Director of the Institute for Energy and the Environment. It is an essential resource for scholars, policymakers and others interested in the future for storage technologies in transportation and electricity, the sectors of the economy that produce the most greenhouse gases. Professor Jones brings considerable expertise to the project, having produced well-regarded reports on smart grid issues, and some projects mentioned in the book – such as the partnership between Tesla and Green Mountain Power – are located in the authors' home state. This slender volume presents a wealth of information in its 170 pages. It addresses subjects ranging from the scientific origin of electric batteries and the damaging impacts of mining the minerals needed to make modern batteries, to the descriptions of potential contributions by storage technologies in the electric grid's ongoing transformation.

The book shines in explaining the wide variety of storage technologies and their applications. "Storage" encompasses a variety of battery and non-battery systems relying on mechanical, electro-chemical, thermal, and electrical technologies. Throughout the book, excellent case studies give a lively and thorough snapshot of recent battery developments and applications. The transportation chapter, for example, describes battery projects in California, Indianapolis, and Norway. Many case studies involve individual manufacturers' plans and activities, so the authors would likely update future editions to reflect market developments.

The book begins with a superb discussion of how batteries can be part of a low carbon future, then takes a detour into a comprehensive history of the electric battery. This presentation has its merits, as there are enough different battery technologies that a working understanding of the science helps differentiate among them. But the lengthy treatment of the scientific background will dissipate some excitement for potential readers, as it precedes any discussion of applications and policy issues. Similarly, the next chapter exhaustively discusses concepts of life cycle analysis as they apply to batteries, which is crucial to evaluating batteries' environmental impacts, but could have been presented later in the book.

The book then moves to its strength, the consideration of the myriad of potential applications for batteries, beginning with Chapter 4 on mobility. It starts with a brief discussion of the potential for electric transportation to contribute to reducing greenhouse gas emissions. Then, it transitions to an excellent analysis combining the history of electric vehicles and legal and policy drivers for their deployment such as modern air pollution regulation, the rise and fall of various attempts to deploy electric vehicles, and current battery technologies and case studies. All of this is presented in an accessible and readable structure. Anyone interested in more depth – say, on laws and policies affecting electric vehicle charging infrastructure development – can find it in sources listed in the book's comprehensive notes, or in other more focused work in law and engineering. The chapter concludes with an intriguing section on the potential for electrified mass transit, discussing exciting developments such as increasing transit electrification in China and the potential for electrifying the heavy-duty vehicle market.

Chapter 5 assesses the potential for batteries to empower consumers of electricity, beginning with a discussion of Tesla's PowerWall and systems offered by Sonnen, a German competitor. As the authors capably describe, whether these systems and others can "radically transform both our homes and businesses" is as yet unclear. On the important issue of whether batteries can satisfy consumers' needs, the authors are clear-eyed realists, noting that "it would be considerably expensive at the moment for a consumer to use Tesla batteries to store all of the electricity she might need for daily use." At the same time, they correctly note that batteries could be "an effective tool for energy arbitrage and electric bill management" through such means as offsets to demand charges, or shifts in electricity usage under time of use pricing. Given the fantastical claims made for some battery systems, this chapter's approach to discussing how a homeowner might use batteries as a backup resource and monetize the battery through different revenue streams is refreshing and balanced, capturing the current reality well.

The chapter concludes with a discussion of four excellent case studies involving utilities and battery storage. As in the transportation chapter, the authors have shown a knack for selecting case studies that best highlight important issues. It would have been useful to draw a sharper contrast between those utilities that are being proactive in conducting battery projects with those whose controversial actions (such as imposing demand charges on solar system owners) merely provide opportunities for batteries to ameliorate the impacts of the utility's actions. Also, the discussion touches only indirectly on the rate recovery process (a utility's ability to recover expenditures through state regulatory proceedings establishing adjustments to consumer rates), which is a critical factor for most utilities in pursuing storage projects.

Chapter 5 also briefly mentions state public policies that promote battery deployment, such as California's regulatory actions and legislation.

California has more storage by far than any other state, given its mandate that requires its three major utilities to install 1.3 GW of storage by 2020, but other states such as Massachusetts are following in California's lead. A slightly longer discussion of states' mandates is in the concluding chapter and would have been better incorporated here. Some comparison of these policies to one another would also have been useful. A previous study by the authors examined state smart grid privacy policies, creating a taxonomy of these policies and discussion that has been enormously influential in the national conversation. Similar analysis, perhaps involving charts and/or tables, would have sharpened the discussion here.

Chapter 6 discusses the potential for batteries to provide services in the wholesale electric grid. With proper regulatory incentives, storage systems could participate in all three types of wholesale electricity markets (energy, capacity and ancillary services): delivering energy, deferring or avoiding costs of new power plants, and providing frequency regulation or other ancillary services more quickly and inexpensively than power plants such as gas turbines. The examination of these opportunities is excellent, as is the discussion of case studies. The chapter concludes by discussing automobile battery reuse for grid storage, and the potential for microgrids that divorce themselves from the grid entirely (although, as has been pointed out elsewhere, a microgrid need not necessarily incorporate battery storage). The discussion of battery reuse illustrates a noteworthy strength of the book. Throughout, the authors have taken great pains to focus both on technologies commercialized today, and those that hold promise for the future.

Without an introduction clearly delineating the distinction between matters subject to federal regulation and the retail electricity distribution system still subject to state regulation, this chapter might leave readers somewhat perplexed. The federal-state division of authority makes storage policy design more challenging. Storage's dual nature – sometimes charging, sometimes releasing – poses unique regulatory challenges, as does the fact that batteries can provide services in both retail and wholesale systems. Storage faces different regulation depending on where it is installed and provides services: behind the meter, at the local distribution system level, or at the wholesale level. Complicating this still further is that FERC's policies promoting storage apply only to electricity markets managed by regional grid operators, not the rest of the nation – which accounts for one-third of electricity consumption. The book should acknowledge that promoting storage is challenging in this jurisdictional landscape, and that the landscape itself is rapidly evolving after recent Supreme Court decisions. Chapter 6 also omits consideration of FERC's proposed rule to encourage storage in the wholesale markets, which was presumably released after the book's publication. In this rapidly changing policy environment, developments of this sort are to be expected.

Chapter 7 discusses the intriguing array of non-battery technologies that hold promise for electricity storage. As it rightly concludes, some are mature and others are not yet “ready for prime time.” Mature technologies include pumped hydro systems that account for the vast majority of installed storage today. These move water uphill to then release it to generate electricity as it flows downhill. More esoteric technologies, such as superconducting magnetic electric systems, are not yet ready for mass commercialization. A chart, table or graph (such as those presented in reports by the national energy laboratories) comparing the different technologies in terms of variables such as their round-trip energy efficiency, response time, and technological maturity would have been useful. Also, the discussion of these technologies might have been shortened in a book that calls itself *The Electric Battery*.

The book concludes with a chapter called “Charging Forward To A Low-Carbon Future.” Given the Trump Administration's recently announced plans to withdraw from the Paris Agreement, and to revisit or withdraw enhanced automobile fuel economy standards and the Clean Power Plan, the section on national policies promoting storage (which focuses on these three major initiatives) will need some updating. It would have been useful here to refer back to FERC's orders contemplating parity between storage and other grid resources, and to discuss other potential legislative, regulatory and R & D initiatives. In a book intended as a background resource and not as a policy white paper, none of this is a serious shortcoming, but a more comprehensive discussion would have made this section stronger.

The book concludes that, “we are beginning to see how state policy innovation and private sector execution can set the economy on a low-carbon path powered by renewable electricity, some of which will be stored in advanced versions of Alessandro Volta's original invention, the electric battery.” Energy storage undoubtedly has a great deal of potential to help us move closer to a clean energy future, but there are many uncertainties. As the book cogently notes, battery technologies have improved in the last quarter century, but not as rapidly as microprocessors governed by Moore's Law. The economics of individual storage projects depend on numerous variables, including location, technology choice, rate structures, and market forces and the incentives contained in applicable regulations. Thus, even the most well-intentioned policies to promote storage might fall short of their ambitious goals. And it is still too early to tell whether non-battery technologies will find widespread adoption, or fade into the dustbin of history. In the end, it would be difficult for a reader of *The Electric Battery* to evaluate the central question it poses: can more storage reduce greenhouse gas carbon emissions, and if so, by how much? For now, however, those who are interested in a comprehensive introduction to energy storage issues will find *The Electric Battery* a valuable resource.

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