THE ELECTRIC BATTERY: CHARGING FORWARD TO A LOW-CARBON FUTURE

By Kevin B. Jones, Benjamin B. Jervey, Matthew Roche and Sara Barnowski

Reviewed by William A. Mogel[*]

This slim book (212 pages), which is packed with lots of energy information in addition to discussing everything you wanted to know about batteries, is the product of the Smart Grid Project at the Vermont Law School's Institute for Energy and Environment. Its Director, Kevin B. Jones, is the lead author. The other authors also are affiliated with the Institute.

The Electric Battery's thesis is that twenty-first century battery technology can be a foundation for a low carbon future: "The battery has emerged as an essential technological component in the push to integrate renewables and decarbonize transportation and the electric grid."[1]

Chapter 1 opens with a ten page synopsis of the history of batteries, offering tidbits such as that the term "battery" was coined by Benjamin Franklin, and Alessandro Volta invented the first battery in 1800, using the "Volta Pile"—the stacking of different types of metals to increase current.[2] In an interesting aside, *The Electric Battery* prudently reminds us that all our cell phones combined consume the same amount of electricity used in 9,000 homes per year.[3]

The following chapter discusses new battery technologies, such as lithium-ion batteries (LIBs)—the "first major leap in battery technology in decades."[4] Other new technologies include lithium sulfur chemistry, flow batteries, such as vanadium redox flow.[5] Based on a review of these technologies, the authors optimistically conclude, "[w]e are in the midst of a battery revolution, with storage technologies poised to dramatically change the way utilities, developers, and regulators approach electricity generation and distribution."[6]

Chapter 3 is entitled "The Battery's Environmental Footprint: How Clean is the Technology?"[7] After a prolonged and unnecessary discussion of "life cycle assessment," it is noted: "[T]he electric battery . . . has both positive and negative environmental impacts. Studies consistently indicate, however, that the electric

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1. KEVIN B. JONES ET AL., THE ELECTRIC BATTERY: CHARGING FORWARD TO A LOW-CARBON FUTURE 4 (2017).
2. *Id*. at 11-14.
3. *Id*. at 19.
4. *Id*. at 33. "Yet, despite their relatively impressive metrics, LIBs have plateaued in their ability to offer increased capacity, power, and longevity for given weights and costs." *Id*.
5. Jones et al., *supra* note 1, at 34-35.
6. *Id*. at 43.
7. *Id*. at 45.

battery offers a lower carbon solution to transportation and [it] can help reduce the carbon intensity of the electric grid."[8]

Chapter 4's thirty pages deal with the use of batteries in transportation.[9] The authors state at the outset: "[T]here is no path to combating climate change that doesn't adequately address carbon pollution and other greenhouse gas emissions from transportation."[10] It is confidently asserted that, even with current battery technology, electric vehicles (EVs) "can meet 87 percent of Americans' daily driving needs."[11] The chapter goes on to discuss EV development, China as the world's leading EV manufacturer, the EV battery ("indirectly. . . the biggest factor in consumer purchasing decisions"), EV range ("every kWh of [battery] capacity provides roughly three to four miles of range"), battery recycling, and mass transit (busses).[12] Also discussed is California's leadership in EV sales (54 percent of the U.S. market in 2015) and Norway's role as the global leader in EV sales.[13] Chapter 4 concludes, without supporting authority, but wishfully:

> It is clear that electric batteries are going to play a major role in both electrifying mobility and transitioning to a low-carbon economy. . . . [I]nvestments must continue to be made in R&D. If resources are invested, we can expect that batteries will become lighter, smaller, more efficient, longer lasting and feature greater range. That burden falls [to] the government, which has the ability to provide incentives to increase adoption.[14]

Chapter 5 offers an enthused endorsement to manufacturers of batteries — Tesla's Powerwall battery ($3,500.00) and larger cousin, PowerPack ($25,000.00), as well as Germany's Sonnen.[15] The authors claim that batteries for the home and business have several end-use opportunities beyond transportation: "[P]rovide the customer with backup power when the local electric grid is down or give the consumer the option to manage either home solar generation or off-peak electricity to generate value from energy arbitrage."[16]

The balance of Chapter 5 discusses such disparate subjects as distributed energy resources (DER), peak/off-peak pricing, innovative rates, and demand charges, all of which energy professionals are familiar with.[17] It concludes that

8. *Id*. at 58-59. Unfortunately, terms such as "intensity of the electric grid" are not defined.

9. *See generally* Jones et al., *supra* note 1, at 61-92.

10. *Id*. at 62. The U.S. "transportation sector accounts for 26 percent of greenhouse gas emissions . . . ranking second to electricity generation." *Id*.

11. *Id*. at 63. Unfortunately, the book relegates citations to authorities to a section at the end. It would be preferable if the cites were located at the bottom of the page or, at least, following each chapter.

12. *Id*. at 71-72, 76-78, 86-90.

13. Jones et al., *supra* note 1, at 83, 85.

14. *Id*. at 91.

15. *Id*. at 95-97. "The PowerPacks can be grouped to scale from 500kWh to over 10mWh and can be utilized for two-hour or four-hour [periods]." *Id*. at 96.

16. *Id*. at 95.

17. *See generally* Jones et al., *supra* note 1, at 95-120. Entities using innovative rates for solar and storage are Salt River Project, SMUD and Green Mountain Power. *Id*.

there is a business case for battery storage, provided that "challenges . . . [can] be overcome."[18]

In Chapter 6, batteries for grid storage are reviewed, along with renewable energy, microgrids, and the use of end-of-life car batteries.[19] Unfortunately, the discussion is overly long and breaks no new ground, possibly except the observation that "[g]rid battery storage is beginning to demonstrate meaningful growth opportunities. The continued development, as well as the declining cost, of lithium-ion batteries will continue to support this growth."[20]

The next chapter catalogues alternative forms, some familiar and some not, of electric storage — pumped hydro, flywheels, compressed air, liquid air, molten salt, thermal ice and water, rail energy storage (to replace water), super conducting magnetic energy storage, supercapacitors, and pumped heat.[21] Ultimately, the test for the best form of storage "is how quickly the stored energy can be discharged."[22]

The concluding chapter is beyond batteries and more about other factors that can have a positive impact on our environment.[23] Cited are the Paris Agreement (to which the U.S. is no longer a signatory), which the authors believe is "the most notable positive development in international climate policy;" ending fossil fuel subsidies (which may be inconsistent with the Administration's policy toward coal); advancement in CAFÉ standards; implementation of the Clean Power Plan (slowed by court review); and consistent state policies toward, *inter alia,* battery storage development.[24]

Despite the observation that 2015 was a "breakout year for the U.S. energy storage market," *The Electric Battery* does not successfully make the argument that the electric battery is "charging forward."[25] Clearly, there has been growth in the use of batteries, especially in conjunction with renewable energy and for transportation. But what was not discussed is when and if batteries will be used in conjunction with generation from fossil fuels. It is that combination which will provide us with a low carbon future.

18. *Id*. at 119.
19. *Id*. at 121-38.
20. *Id*. at 138.
21. *See generally id*. at 139-58.
22. Jones et al., *supra* note 1, at 140.
23. *See generally id*. at 159-69.
24. *Id*. at 161-64.
25. *Id*. at 169 (citation omitted).