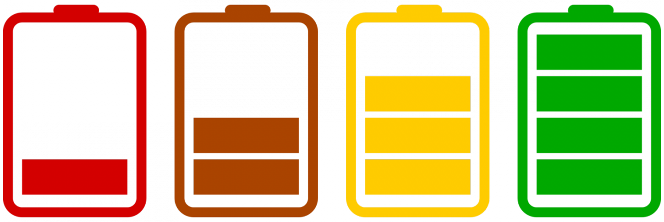
Combined economic and technological evaluation of battery energy storage for grid applications

4 December 2018, by Daniel Kane



Credit: CC0 Public Domain

Connecting large battery systems to the energy grid offers the ability to capture and store renewable energy during the windy and sunny times, and then use the stored energy during less sunny and less windy times. No surprise there.

Integrating batteries into the grid requires that they provide operators with enough revenue to participate. But figuring out what kind of batteries should be connected is complicated, for many different reasons. One reason for this is that the decision needs to account for a host of variables including battery chemistry, the tasks the batteries will be performing most often (which extend well beyond simple energy storage and retrieval), as well as the intricacies of market rules and energy pricing.

While the idea of accounting for battery type, battery task, price, and market rules may sound like common sense, combining these analyses is complicated, and often not done. Or at least not done as thoroughly as necessary to make the best financial decisions when it comes to selecting grid-connected battery storage.

That's where a team of engineers and economists from the University of California San Diego enters the picture.

A new study in *Nature Energy* from the labs of UC San Diego nanoengineering professor Shirley Meng and UC San Diego economics professor Graham Elliott offers a combined chemistry-and-economics approach that should make it easier to identify which kinds of batteries are best suited for particular applications on the California energy grid and beyond.

The researchers are developing a suite of open-source tools that they hope will be useful in California and elsewhere.

"You can't look at cost per megawatt hour of storage as some absolute number that is fixed. That's not how battery systems work, and the complexities grow even more when you're looking at grid-connected systems," said UC San Diego nanoengineering professor Shirley Meng. "You need to look broadly in order to get an accurate picture of what's going on financially with grid-connected batteries. That's why we are collaborating with economists. To make a real impact, you need think beyond the lab," said Meng.

Energy storage is critical to bringing renewable and lower cost energy sources to the grid.

"Battery systems need to be financially viable for operators before they will be connected to the grid," noted UC San Diego economics professor Graham Elliott. "This depends on hosts of factors, from the markets for energy and the characteristics of the batteries themselves. Our work is a step in better understanding the link between these two aspects."

The short excerpt below from the conclusions section of the new *Nature Energy* paper offers a glimpse into both the approach and impact of this kind of work.

"Contrary to the current literature, we show that to accurately gauge the potential revenue of an energy storage technology on the grid, it is insufficient to assume constant efficiencies across different applications. As an example, for the lithium iron phosphate (LFP) battery, if one were to assume that the efficiency of the time-shift application (93.1%) was consistent across all of the battery applications, this would result in a substantial error in the calculations of revenue. For congestion, ramping and frequency-regulation applications, the percentage error in calculated revenue would be 6, 11 and 15% respectively."

Sustainable Power and Energy Center at UC San Diego

This collaboration is part of the interdisciplinary work of the UC San Diego Sustainable Power and Energy Center, where Shirley Meng serves as Director, and Graham Elliott is a faculty member. Research at the Sustainable Power and Energy Center extends from theoretical research through experiments and materials characterization all the way to real-world testing of devices on the campus microgrid. The Meng Lab, for example, is pursuing many different lines of research aimed at devising better ways to understand how batteries function, often in real time, from the nanoscale to the system level.

Toward Open Source Tools

"Existing public studies on revenue generation do not give precise answers to valuation for any particular chemistry or market location," said Elliott. "Our programs are focused on one part of the market, but having focused on this provides results that are as close to operating a battery on the grid as we could."

The UC San Diego researchers are making all the protocols and economic evaluation tools open source and available to the public. They note that these protocols and evaluation tools need to be modified for different grids (e.g. New York has different market rules from California), "so care should be exercised when using these tools," said Meng.

This study focuses on the performances of the fundamental building blocks (cell-level batteries) of these storage systems for a variety of applications and future work will take the effects of additional variables, such as power electronics, into account.

"Data limitations on market operation, especially understanding quantities of energy demanded through regulation and ramping products, also hamper our ability to understand fully the value of batteries in the markets," said Elliott.

More information: D. M. Davies et al. Combined economic and technological evaluation of battery energy storage for grid applications, *Nature Energy* (2018). DOI: 10.1038/s41560-018-0290-1

Provided by University of California - San Diego