6-2017

Is electricity storage green? A study on commercial buildings

Yangfang (Helen) ZHOU
Singapore Management University, helenzhou@smu.edu.sg

Is electricity storage green? A study on the commercial sector

---

Electricity storage facilities, such as industrial batteries, are frequently called the "game changer" in de-carbonizing the electrical grid. The U.S. has enacted laws to encourage the adoption of storage technologies, citing as one of the major reasons their potential in reducing carbon emissions. For example, California mandates that an additional 1,325 megawatts (MW) of electricity be procured from electricity storage by 2020 (California Public Utilities Commission 2013); Oregon and Massachusetts have passed similar bills that require setting a mandate (in MW) on energy storage (Oregon Government 2015, Massachusetts Government 2016). Other states have introduced incentive programs to promote storage, such as Texas, New York, and Washington (DOE 2013).

We examine the environmental impact of electricity storage deployed in the commercial sector (one of the three major sectors by electricity end use), such as retail stores, corporate offices, and educational institutions. The commercial sector, almost entirely commercial buildings, consumes 35% of electricity generated in the U.S. in 2015, which accounts for 18% of the total carbon emissions in the U.S. in 2015 (EIA 2017). Electricity storage systems are being adopted in commercial buildings in the U.S.; for example, Target and Amazon have been collaborating with Telsa to use its batteries in powering their retail stores and data centers, respectively (Telsa Energy 2017). Other examples of commercial buildings with electricity storage systems include Barclay Towers and other office buildings in New York City (Demand Energy 2016). In fact, experts predict that "The behind-the-meter sectors ... will account for half of the 2021 annual storage market" (Greentech Media Research 2016), where behind-the-meter sectors refer to both commercial and residential sectors. Similarly, experts from Bloomberg (Bloomberg New Energy Finance 2016) forecast a surge in behind-the-meter energy storage.

Electricity storage is potentially valuable for commercial buildings mainly for two reasons. First, electricity storage can help reduce demand charge, a charge proportional to the *maximum* 15-minute electricity consumption within a billing cycle (usually a month). Demand charge accounts for about 30% of the electricity bill for a commercial building in the U.S. and can go up to as high as 50% (Neubauer and Simpson 2013). Second, storage is particularly attractive to a commercial building if the building is already equipped with a solar photovoltaic (PV) power generation system, as a storage facility can stock any generated solar energy that exceeds demand, and discharge it at a later time to satisfy demand when the sun is not shining. Bloomberg New Energy Finance (2016) projects that coupling with solar power may become the main driver of installing storage for a commercial building.

We model the problem of managing electricity storage in a commercial building, for both the cases with and without a solar PV system, as a Markov Decision Process. We characterize the structure of the optimal policy in operating storage, generalizing known policy structures in the literature. In an extensive numerical study, we evaluate the impact of storage operations in a commercial building on carbon emissions, i.e., whether the addition of storage in a building increases or decreases carbon emissions. We perform our analysis for 100 commercial buildings, spread across five U.S. cities, the demand data of which we obtain from EnerNOC. For each commercial building, we calibrate our electricity demand model to its demand data and our solar energy model to its solar irradiance data obtained from NOAA, and then compute the optimal storage (charging and discharging) action in each period within any given billing cycle, based on the electricity tariff obtained from its utility company. To examine the net effect of the computed storage operations on carbon emissions, we multiply these storage operations with marginal emissions factors (emissions incurred for satisfying a unit of electricity demand), estimated by Siler-Evans et al. (2012), for the electrical reliability region where the commercial building belongs.

For the case when the commercial building is not PV-equipped, our preliminary numerical results show that the optimal storage operation *increases* net carbon emissions for all 100 commercial buildings. This increase in net emissions is true regardless of the season, and regardless of whatever realistic value is used for the efficiency of electricity storage. The reason for this increase in carbon emissions is two-fold. First, as the demand for most commercial buildings is low at night and high in the day time, the optimal storage operation charges at night, from “dirty” sources, and discharge in the day time, displacing “clean” sources: “dirty” sources, such as a coal plant (the usual night-time marginal generator), have higher carbon emissions intensities than “clean” sources, such as a natural gas plant (the usual day-time marginal generator), so the net effect of storage operations is to increase emissions. The second reason lies in the storage facilities’s efficiency loss: more electricity is required to charge the storage facility than that can be extracted from it, thus releasing more carbon. This second effect is why storage also increases carbon emissions for commercial buildings with a “reversed” demand profile, where the demand is high at night and low in the day time:

even though the first effect predicts that the optimal storage operations in such buildings would decrease emissions, the second effect dominates the first. We also find that only when storage is unrealistically efficient (say 95% to 100%) could storage operations in such buildings decrease carbon emissions.

We are currently analyzing the case when the commercial building is already PV-equipped.

Our numerical result on storage's environmental impact has significant policy implications: Contrary to the common belief of policy makers (as well as the advertising of electricity storage developers), electricity storage deployed in commercial buildings is not necessarily green.

References

Bloomberg New Energy Finance. 2016. Global energy storage forecast, 2016-24.

California Public Utilities Commission. 2013. Decision adopting energy storage procurement framework and design program. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M078/K929/78929853.pdf.

Demand Energy. 2016. Demand energy achieves project milestone for 2 mwh of energy storage projects in new york. Available: http://demand-energy.com/pressroom/latest/196-demand-energy-achieves-project-milestone-for-2-mwh-of-energy-storage-projects-in-new-york.

DOE. 2013. Grid energy storage. https://energy.gov/sites/prod/files/2014/09/f18/Grid%20Energy%20Storage%20December%202013.pdf, last assessed Feb, 2017.

EIA. 2017. U.S. monthly energy review. http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf, last assessed in Feburary, 2017.

Greentech Media Research. 2016. U.s. energy storage monitor. Available: https://www.greentechmedia.com/research/subscription/u.s.-energy-storage-monitor, last accessed in Feburary, 2017.

Massachusetts Government. 2016. An act to promote energy diversity. https://olis.leg.state.or.us/liz/2015R1/Downloads/MeasureDocument/.

Neubauer, J., M. Simpson. 2013. Deployment of Behind-The-Meter energy storage for demand charge reduction. Tech. rep., National Renewable Energy Laboratory.

Oregon Government. 2015. House bill 2193, relating to energy storage; and declaring an emergency. https://olis.leg.state.or.us/liz/2015R1/Downloads/MeasureDocument/HB2193.

Siler-Evans, Kyle, Ines Lima Azevedo, M Granger Morgan. 2012. Marginal emissions factors for the us electricity system. *Environmental science & technology* **46**(9) 4742–4748.

Telsa Energy. 2017. Tesla energy for businesses. https://www.tesla.com/presskit/teslaenergy.