On the System Value of Commercial and Industrial Behind-the-Meter Solar PV plus Energy Storage: The Importance of Retail Rate Design

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Overview

The electricity sector is undergoing a period of substantial transition with the increased deployment of distributed energy resources (DERs) that can take the form of rooftop solar panels, energy storage, and demand-side management. The declining costs of solar PV and storage has raised substantial interest in the future of combined "PV plus storage" systems. Rooftop solar has grown exponentially in California due in large part to retail rate design, cost reductions, and financial incentives (Borenstein, 2017). Further, the cost of storage has declined by an average of 23% per year from 2010 to 2015 (Ardani et al., 2017). California has also introduced ambitious targets to procure 1.3 gigawatts of storage by 2020, with approximately 200 megawatts targeted for behind-the-meter storage (CPUC, 2013a). In addition, California provides subsidies for storage of up to $1.62/watt (CPUC, 2018).

Existing research has demonstrated the potential profitability of behind-the-meter PV plus storage systems for commercial and industrial consumers (e.g., Neubauer and Simpson, 2015; McLaren et al., 2018). The complementarity between variable PV output and controllable energy storage allows consumers to manage peak demand. This can allow commercial and industrial consumers to lower their monthly maximum demand charges which can reflect 30% - 70% of a consumer's bill (NREL, 2017).

The anticipated growth and potential value of PV plus storage (and other DERs) has motivated California regulators to require utilities to adjust existing tariffs and create optional tariff structures for consumers that invest in DERs. This has led to numerous tariff proposals by large investor-owned utilities (PG&E, SCE, SDG&E) and environmental and solar advocates (e.g., SEIA) (CPUC, 2015). The proposed tariffs include various components related to the design of time-of-use prices and maximum demand charges. These proposed tariffs will have substantial implications on investment and operation of behind-the-meter PV plus storage systems.

We investigate the impacts of existing and proposed tariff structures on both the investment incentives and the system value provided by PV plus storage systems installed for behind-the-meter applications. We focus on the implications of different tariff structures on storage charge and discharge decisions and compare these decisions to the time-specific avoided cost of providing electricity services. This research complements the existing literature which has largely focused on the economic incentives of commercial and industrial consumers to invest in behind-the-meter PV plus storage across different tariff structures (e.g., Neubauer and Simpson, 2015).

Methods

We utilize the Distributed Energy Resources Customer Adoption Model (DER-CAM) to estimate both the optimal solar PV plus storage investment decisions and the optimal hourly storage charge and discharge profiles (LBNL, 2018). We use hourly demand data of twenty-two large commercial and industrial consumers in the Los Angeles region as representative load data provided by EnerNOC (2013). We use hourly solar radiation and weather data from the National Solar Radiation Data Base (NSRDB, 2018), geo-located to each of the twenty-two consumer sites.

We utilize the Marginal Avoided Cost Model utilized in CPUC (2013b) and E3 (2016) in the Distributed Energy Resource Avoided Cost Proceedings to capture the potential value of PV and PV plus storage systems. This data provides a detailed model for calculating the avoided cost associated with a unit of output from a DER. We separate the avoided cost associated with reducing a consumers' consumption from the utility by utilizing DERs into two categories. First is the avoided energy, line losses, ancillary services, and environmental compliance costs due to reduced consumption of variable electricity services from the utility. Second is the avoided capacity costs associated with building generation, distribution, and transmission capacity. There has been significant debate over whether or not DERs can provide capacity value via the reduced need for generation, distribution, and transmission capacity.

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We utilize existing retail tariffs for commercial and industrial consumers for the SCE region as our baseline tariff structure. We then analyze the impact of the proposed tariff structures currently being debated at the California Public Utility Commission (CPUC, 2015). We compare the optimal investment decisions in PV plus storage and the behind-the-meter charge and discharge decisions to SCE's time-specific avoided costs.

Results

We find that the design of maximum demand charges and the precise definition of on-peak, mid-peak, and off-peak hours in time-of-use pricing mechanisms plays a significant role in the charge and discharge decisions of energy storage. For example, shifting on-peak hours from 12 PM - 6 PM to 3 PM - 8 PM can motivate large consumers with PV plus storage systems to charge via on-site solar PV during the day and discharge during the evening hours where the system is facing substantial ramping needs due to the infamous "duck curve". Increases in the peak and off-peak price differential can elevate the value of behind-the-meter PV plus storage systems. Adjusting demand charges to reflect coincidental peak demand has the potential to better align storage charge and discharge decisions with regional network value. We find that the proposed shift in the on-peak period reduces the compensation to PV and PV plus storage systems. While this reduces investment incentives in behind-the-meter DERs, it also alleviates cross-subsidy concerns that exist in the current tariff structures.

Conclusions

We utilize an optimization model to investigate the network value of commercial and industrial behind-the-meter solar PV plus storage systems in California. The previous literature has largely focused on the impact of retail rate design on the economics of PV plus storage systems. We emphasize the important role that retail rate design has on the electricity system value provided by behind-the-meter PV plus storage. Our analysis provides support for recent movements in California to redesign their retail tariffs to better reflect network value. We highlight various tariff features that increase the system value of behind-the-meter PV plus storage systems. This provides a deeper understanding into the important retail tariff features in the face of the numerous competing tariff proposals.

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