BATTERIES AND ELECTRICITY MARKET DESIGN FOR RESIDENTIAL PROSUMERS

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Overview

The ongoing restructuring of power systems towards a renewable-based electricity system has prompted the discussion of assessing new electricity market designs. The integration of end-users not only as consumers but also as producers of electricity poses an alternative to the classical market structure. For example, it remains unclear what the value of cooperation among prosumers in a micro-grid is. This paper investigates how individual houses with battery storage, cooperate to achieve self-sufficiency. We discuss the market design for a neighbourhood of prosumers: What if prosumers can trade with their neighbour first before they procure electricity from the grid? The paper assesses the value of cooperation between prosumers in a closed micro-grid (e.g. Mengelkamp et. al. 2017) to determine: Should batteries be deployed at either house or community level, or at both levels simultaneously? And, how do heterogeneous prosumers cooperate and interact in a micro-grid setting to achieve high levels of self-sufficiency?

In this paper, we assume that prosumers (at the household level) mainly aim at being self-sufficient, meaning independence of electricity supply from the grid. Even though this goal is often not met, this opens a new kind of electricity market design specialized to a neighbourhood of prosumers (Green and Staffell 2017; Mengelkamp et. al. 2017). We consider a cooperative community of prosumers confined in a microgrid system and we model the trade between each neighbouring household to minimize the utilisation of the main grid. Integrating the cooperative end-user energy production and storage to electricity markets (local and centralized) implicates an economic benefit in terms of efficient grid utilisation as well as decreasing electricity prices for the end-user.

Methods

We developed a techno-economic bottom model based on linear programming (Crespo Del Granado, P. et. al. 2014) that optimizes the operations of batteries and energy units. The objective function is to minimize the cost of buying electricity from the main grid and from fellow household prosumers. That is, each house optimizes its battery schedule based on RES production, grid prices, and neighbours' possible surplus from RES.

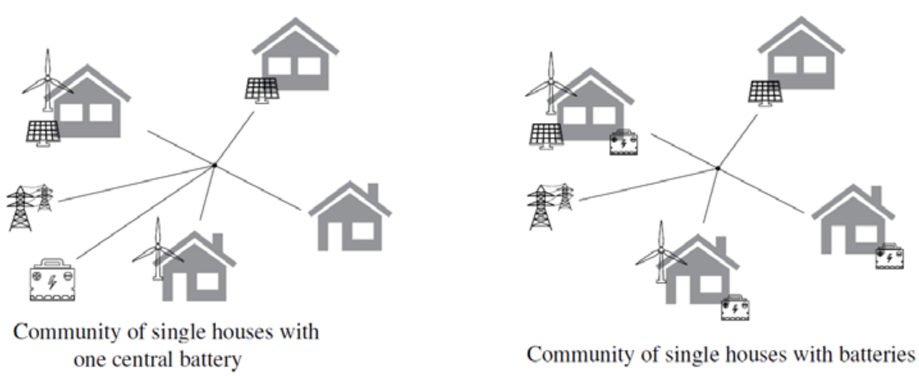

Figure 1: Cases implemented in the analysis: A Battery per House or a Big One for All?

We setup and compare two cases: the first case considers a large battery installed for an array of houses and in the second case each individual prosumer installs a battery for self-balancing and trading purposes. The analysis is implemented to a real-life neighbourhood (10 houses) of typical houses in the United Kingdom.

Results

We found that battery storage lowers a single prosumer's costs significantly (up to 15% reductions in the energy bill). This leads to the question whether the value of storage could even increase in a community of such prosumers. It could be argued that the connection of prosumers would generate even higher savings as they can interact among themselves. Can the consideration of battery storage enable savings not just in a single residential house but also in an interconnected community? Preliminary results show that the value of storage in both cases (large battery versus individual batteries) does not vary significantly. But, for some households the large battery case makes more economic sense compared to their counterparts (this is mainly due to greater balancing needs to match local PV production with load for some houses). We are determining the trading benefits among houses and implementing different price schemes to come up with recommendations on how a local electricity market rules could be designed for prosumers. For example, we observe that for the 10 houses, the formation of a supply and demand curve for the power exchange are mainly dominated by two large houses energy demand at night while at midday smaller houses PV-storage interactions decreases local prices by 30% compared to the main grid prices.

Conclusions

By determining the value of cooperation for prosumers among themselves, this work in progress paper aims to provide new insights on how future bottom-up electricity markets can be designed to integrate large shares of distributed renewable energy sources and put prosumers as an active market participant. To our knowledge, the possible interaction between heterogenous prosumers with batteries has not yet been comprehensively addressed in the literature.

References

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