STRATEGIC APPLICATION OF RESIDENTIAL BATTERY SYSTEMS: NEW GRID SERVICE MODEL OF PV SELF-CONSUMPTION

Hyun Jin Julie YU, CEA (French Alternative Energies and Atomic Energy Commission), Phone +33169086710, E-mail:julie.yu@cea.fr

Overview

PV energy has demonstrated visible progress over the last decade as an alternative source of energy to traditional fossil fuels. The world cumulative installed solar PV capacity has been largely increased from around 600 megawatts (MW) in early 2000 to around 230 gigawatts (GW) in 2015. The coupling market dynamics of PV sector and Li-ion batteries will enhance the economics of residential PV self-consumption in the near future. When PV self-consumption systems become economically competitive in the near future, end-users will be willing to switch to PV self-consumption instead of using power from the network.

However, the large penetration of PV systems in the electricity mix causes the systemic effects (ex. additional costs related to PV integration into the existing electricity system). The large part of systemic costs concerns the backup power system associated with variable PV integration. However, these costs vary from one country to another because of different energy profiles. For example, France requires the higher costs of backup power compared with other regions like California: France's annual electricity consumption peaks occur in the winter evenings. This means that the massive and rapid PV integration without systemic strategies can affect the energy system and stakeholders.

In this context, this study aims to propose an innovative grid service model using residential battery systems to address systemic effects that can be caused by a large integration of PV power. The article defines the market demand of residential PV self-consumption systems with batteries without political supports: French data are used for modelling. This article identifies opportunities of strategic usage of residential battery systems. Our optimization model suggests a strategic utilization of residential batteries when they are not in use (ex. in winter months). This article demonstrates how this innovative mode of battery usage reduces systemic effects of PV integration. For example, we evaluate to what extent this model can address the systemic effects with regard to balancing and seasonal back up capacities. We then give our economic analysis of the grid service model. The study concludes with key messages and policy recommendations to prepare the proper institutional and political strategies.

Methods

The study includes the following steps and assumptions:

1. Develop a scenario to define market demand without political support: French residential PV self-consumption with batteries in the near future in 2030 (according to author's residential PV self-consumption model with Li-ion batteries).
2. Based on the defined scenario, the average residual grid power consumption is analyzed for each month: periods of low demand and of high demand in a day.
3. Develop our battery model to propose new grid services: key parameters to manage batteries.
4. Evaluation of benefits associated with systemic effects (e.g. balancing, bank-up capacities).
5. Assessment of the economics of the proposed grid services model (e.g. breakeven prices).
6. Policy recommendations and conclusion.

Results

- Our model based on 80% residential PV self-consumption model: an aggregated demand of 56 GWp PV + 75 GWh of storage capacities (3kWp PV system + 4kWh batteries).
- Battery use rate is low: 60% throughout the year. (100% = 1 full cycle per day).
- Benefits from our new grid service model:

Optimization of battery use	Increase of battery use rate to 74%
Balancing-related	Decrease of daily variations (Max – Min) with battery grid services: e.g. 8.4 GW (Dec.)
Back-up capacity	Possible reduction of 4 GW of annual peak demand

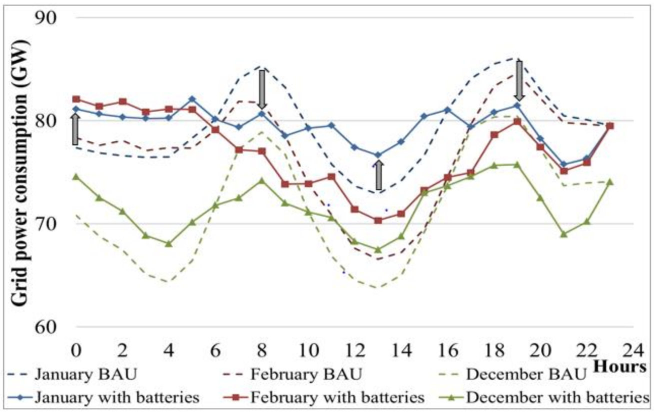

Figure 1: Grid services to smooth the demand curves.

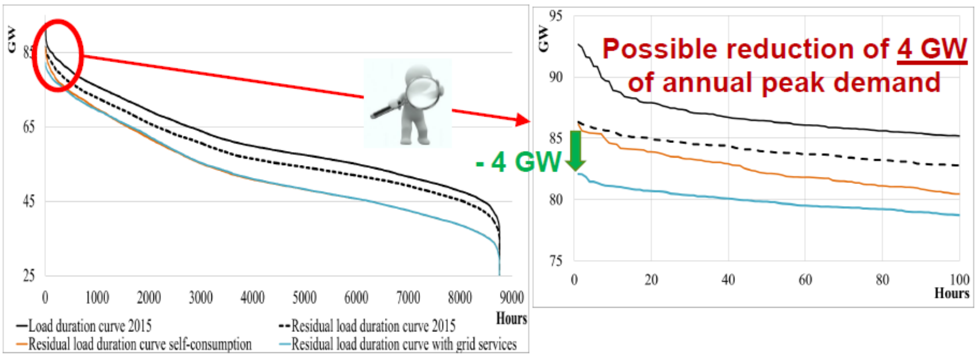

Figure 2: Grid services to contribute to back-up capacity.

Conclusions

- The proposed optimization model of residential battery usage increases the rate of battery use during winter and provides grid services that contribute to address balancing and back up issues.
- This model needs a relatively simple & standardized control systems with functions (the conditions to be defined).
- It can enhance profitability of residential PV self-consumption systems: revenue creation when grid operators, aggregators or system providers are allowed to use capacities of residential batteries during winter.
- Risks: demand peak shift in different timeslots & rapid change in demand related to battery charging (concurrent automatic charging)
- Our model needs to liaise with more sophisticated solutions to smooth the start/end of charging/discharging of batteries.
- New business models & sector coupling can be further discussed based on our innovative optimization model of residential battery usage.
- Policy has an important role in developing this model (e.g. regulation, standardizations, system innovation).

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