World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:14, No:01, 2020

Decentralized Peak-Shaving Strategies for Integrated Domestic Batteries

Authors : Corentin Jankowiak, Aggelos Zacharopoulos, Caterina Brandoni

Abstract : In a context of increasing stress put on the electricity network by the decarbonization of many sectors, energy storage is likely to be the key mitigating element, by acting as a buffer between production and demand. In particular, the highest potential for storage is when connected closer to the loads. Yet, low voltage storage struggles to penetrate the market at a large scale due to the novelty and complexity of the solution, and the competitive advantage of fossil fuel-based technologies regarding regulations. Strong and reliable numerical simulations are required to show the benefits of storage located near loads and promote its development. The present study was restrained from excluding aggregated control of storage: it is assumed that the storage units operate independently to one another without exchanging information – as is currently mostly the case. A computationally light battery model is presented in detail and validated by direct comparison with a domestic battery operating in real conditions. This model is then used to develop Peak-Shaving (PS) control strategies as it is the decentralized service from which beneficial impacts are most likely to emerge. The aggregation of flatter, peak- shaved consumption profiles is likely to lead to flatter and arbitraged profile at higher voltage layers. Furthermore, voltage fluctuations can be expected to decrease if spikes of individual consumption are reduced. The crucial part to achieve PS lies in the charging pattern: peaks depend on the switching on and off of appliances in the dwelling by the occupants and are therefore impossible to predict accurately. A performant PS strategy must, therefore, include a smart charge recovery algorithm that can ensure enough energy is present in the battery in case it is needed without generating new peaks by charging the unit. Three categories of PS algorithms are introduced in detail. First, using a constant threshold or power rate for charge recovery, followed by algorithms using the State Of Charge (SOC) as a decision variable. Finally, using a load forecast – of which the impact of the accuracy is discussed – to generate PS. A performance metrics was defined in order to quantitatively evaluate their operating regarding peak reduction, total energy consumption, and self-consumption of domestic photovoltaic generation. The algorithms were tested on load profiles with a 1-minute granularity over a 1-year period, and their performance was assessed regarding these metrics. The results show that constant charging threshold or power are far from optimal: a certain value is not likely to fit the variability of a residential profile. As could be expected, forecast-based algorithms show the highest performance. However, these depend on the accuracy of the forecast. On the other hand, SOC based algorithms also present satisfying performance, making them a strong alternative when the reliable forecast is not available.

Keywords : decentralised control, domestic integrated batteries, electricity network performance, peak-shaving algorithm
Conference Title : ICEST 2020 : International Conference on Energy Storage Technology
Conference Location : Sydney, Australia
Conference Dates : January 30-31, 2020