BESS-FACILITATED LOCAL ENERGY MARKET: A CASE STUDY ON TYPICAL AUSTRALIAN CONSUMERS

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Overview

In this paper, we outline the results of a case study using real Australian customer data to evaluate the performance of peer-to-peer (P2P) trading in the local energy market (LEM) in comparison with business-as-usual (BAU), where the prosumers sell their excess generation via feed-in-tariff (FiT) and consumers buy energy from the grid. The battery energy storage system (BESS) is also included in the LEM model to introduce greater flexibility and capture the implications on electricity costs along with grid export and import. The performed P2P case study consists of 260 participants in a typical Australian suburb. Of these participants, 180 are consumers, 40 are prosumers with solar photovoltaic (PV) systems, and 40 are prosumers with solar PVs and BESSs. When compared to the BAU, the results show that consumers, prosumers with solar PV systems, and prosumers check with solar PV and BESS can reduce their average electricity costs by 5.7%, 8.6%, and 22.7% respectively. Further, grid export and import are reduced by 42.6% and 16.5% respectively. It is to be highlighted that the aforesaid savings and grid benefits are without altering the network fees and retailer margins. This demonstrates mitigation in congestion and lesser dependency on the grid and reducing or deferring capital expenses for network augmentation.

Methods

LEM enables participants (both consumers and prosumers, within a defined network topology, to trade renewable energy amongst each other in a P2P fashion [1-2]. Through a distributed trading platform, participants can match buy and sell offers in forward-facing time intervals, and hence receive better financial returns compared to the FiT scheme [3]. The blockchain-based distributed energy trading platform has already been developed by Powerledger [4], which can be extended to accommodate LEM. Multifarious goals of participants, that include minimising energy bills, attaining self-sufficiency, and becoming sustainable users and flexible dispatchers are managed in the LEM through accurate economic planning [5]. Further, while LEM has the potential to reduce grid's export and import during solar PV and peak periods, the demand-side flexibility of the energy users is also increased [6]. Moreover, LEM promotes decarbonisation, digitalisation, decentralisation, and democratisation of energy using P2P trading and customer empowerment [7].

Our forward-facing LEM platform involves the following steps are to:
Step 1: Collect historical load; solar PV; and BESS data, and electricity and FiT prices from the retailers.
Step 2: Identify sellers (who have excess energy) and buyers (who have energy deficiency) based on the energy statuses.
Step 3: Adopt our new rule-based P2P optimisation technique to clear the LEM trading decentrally, in which both sellers and buyers' orders are optimised within the given constraints; excess energy and energy deficiency are matched; bilateral transactions are conducted; and the P2P market is cleared.
Step 4: Compare the outcomes with BAU and evaluate performance to promote the applicability of our LEM product.

Results

In this study cross retailer trading is considered among two different retailers. The average data profiles are taken from 260 participants, who are usual customers of two different retailers, namely AGL as Retailer 1 [8] and Origin as Retailer 2 [9]. The objective function to perform the analysis is minimising the cost of LEM components [10] to gain optimum values. The network distribution and transmission fees are taken from Endeavour energy, NSW database [11].

Figure 1 demonstrates the average electricity cost of consumers, prosumers with solar PV, and prosumers with solar PV and BESS. On average, at BAU, these participants are billed approximately $4.65, $3.00, and $1.80 respectively. Strikingly, our proposed mechanism minimises these costs by 5.7%, 8.6%, and 22.7% respectively.

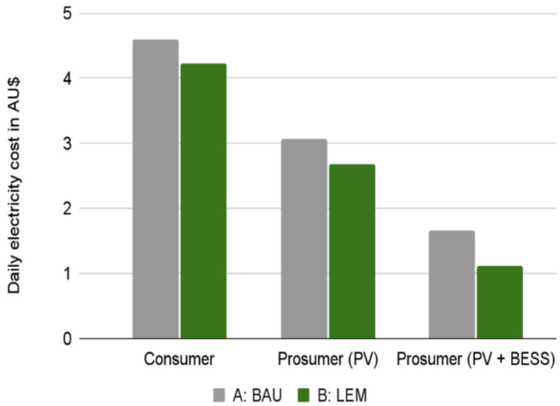

Figure 1: Average electricity cost reduction.

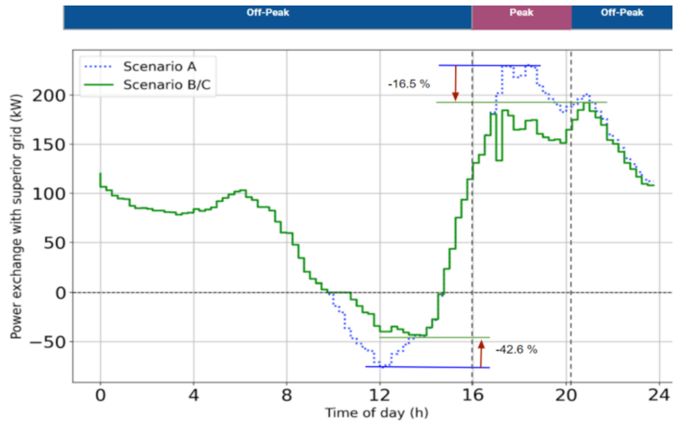

Figure 2: Grid export and import comparison.

Figure 2 represents grid export and import comparison for a typical day. Schema A and Scenario B/C indicate BAU and our developed LEM model. As illustrated, our proposed LEM lessens the grid export in peak afternoon time by 42.6% compared to BAU. In addition, the grid import during peak demand periods decrease by 16.5% due to the P2P trading among the consumer, prosumer and prosumers with BESS.

Conclusion

A BESS-facilitated LEM case study has been executed using customers' data. It has been found that consumers, prosumers with solar PV, and prosumers with solar PVs and BESSs, can reduce their electricity bills by 5.7%, 8.6%, and 22.7% respectively on average. This can motivate residential customers to participate in P2P trading through Powerledger's LEM platform. Additionally, the grid has been able to cut down export and import by 42.6% and 16.5% respectively, enabling the grid to reduce or defer capital expenses for network augmentation, without altering network fees and retailer margins. This solution would aim to mitigate the issues resulting from high penetration of distributed energy resources in several parts of the world such as in Australia, Kyushu region in Japan and in California.

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