VALUE OF PROSUMER HOUSE BATTERIES: EXPERIENCES ACROSS THE EU

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Overview

According to the EU Strategy Energy Technology Plan, consumers (or energy 'end-users') are envisioned to be at the center of the energy transition. It mainly implies that an active engagement of end-users will prompt a greater support to reach change climate goals for a low carbon energy system. A successful effort to actively involve the end-user is the ongoing deployment and adoption of solar PV. Solar has proven to be a viable technology for the end-user mainly due to policy incentives and its declining costs. Today, a similar narrative is starting to take place for electrical vehicles (EV) batteries and storage technologies. Batteries are a long-sought technology to balance renewable fluctuations and it is expected to be a key technology in the energy transition (Crespo del Granado, P. et- al- 2016). Could batteries be the new technology deployed on mass scale as it is being the case for solar PV? Germany has taken this possibility seriously and is currently subsidizing batteries for households that add a battery system to their PV array.

In this paper, we assess the deployment of batteries at the end-user level across six EU countries: Spain, United Kingdom, Germany, Bulgaria, Norway and Netherlands. Country features affects the batteries viability due to indigenous factors such as electricity prices, solar potentials and the regulatory framework. Through an optimization model that captures the hourly details in supply-demand operations for households, we estimate the value of batteries based on: cost savings from smoothing solar fluctuations and from peak shaving management applications (time of use electricity prices and kWmax control[1]). To find out whether batteries can become profitable for prosumers, the model is implemented on real battery houses being used as pilot demonstration sites in a Horizon 2020 project[2]. We calculate the revenue coming from batteries and check their profitability along with current and proposed subsidies schemes. What are the cost-benefit differentials across current subsides schemes? How the economic potential of batteries varies upon the PV size? As solar plays a decisive role, we look at the sizing effect of PV-battery combinations and discuss the effect on revenue and the role of subsidies. Overall results show that battery produces cost savings in the magnitude of 6-15 %, but these savings have a different monetary value across the EU countries analyzed in the paper, making prosumer house batteries more profitable for United Kingdom and Germany than other countries.

Method

The optimization model used is a linear programming algorithm which minimizes the investment costs and provides optimal sizing of PV and batteries. The model features a rolling horizon information structure with predictions made for PV production, load and electricity prices. It is a multi-period optimization model with emphasis on electricity storage presence in houses that minimizes the marginal cost of supplying energy to the house in hourly basis. The model objective function varies depending on the country features, the house energy system characteristics and price structure of the relevant pilot demonstration project. In the H2020 project INVADE[1] we present the effect of flexibility services on sizing decisions for the prosumer's battery. This is based on three flexibility services: 1) Time of use (ToU) price, 2) kWmax control, and 3) self-balancing. For these services, the battery smooths and integrates local PV production, manages peak demand and handles imports/exports to the grid under a kWmax constraint.

For each country house demonstration pilot or existing household data set, we implement the model and calculate the NPV. This is compared to a 'reference case' which has no battery presence or to different combinations of PV-battery sizes. We also test the role of different price schemes to use storage as a peak-shaving mechanism or for energy arbitrage purposes.

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[1] kWmax control refers to when the end-user is restricted to a certain power limit which can be drawn from the grid
[2] INVADE Horizon 2020: http://h2020invade.eu/

Results

The analysis for the Nowegian case was based on a large household in Trondheim, Norway. The focus was to compare the economic potential of a PV and house battery setup with a PV and EV battery setup. Leveraging the variations in spot price and hourly grid tariff costs, the results showed reduced annual electricity costs under three different grid tariffs. When using a EV battery with rooftop PV, the cost is reduced by 12.0 – 19.2 % (depending on grid tariff structure), while a home battery installation with battery reduces the cost by 8.9 – 14.4 %. In other words, utilizing an EV battery which is considered free would lead to a large savings, whereas a home battery which carries costs would require large subsidies to achieve a positive net present value. This is mostly due to low electricity prices in Norway and low solar production.

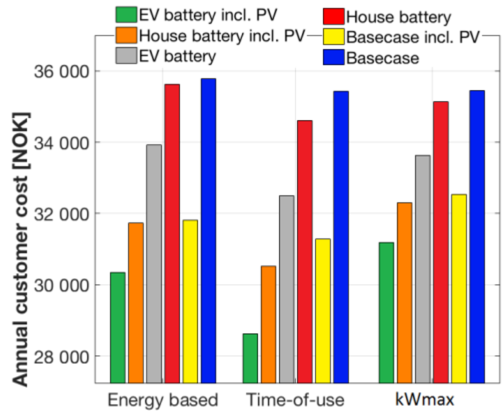

Figure 1: Annual customer cost under different grid tariffs (Norway)

For the case in the Netherlands, the battery is mainly used as a self-balancing flexibility source. For example, the PV case of 1kW (top light blue area), solar production is almost fully consumed by the end-user and hence not violating kWmax exports (below 1kW). The same applies for the 1.25kW solar PV case, which makes the two cases "needless of battery flexibility". That is, the house can handle these solar capacities whithout battery presence. However, as the PV size increases, the harder it becomes to integrate PV into the system (violating kWmax). This is illustrated in the chart area "Battery Flexibility". As for the cost savings, the larger the PV sizes, the higher the savings for batteries. This varies from 5% (1.25kW PV sive and 1.25kWh battery) to up to 17% (2.5kW PV size and 2.75 kWh battery) in reductions to the annual electricity bill.

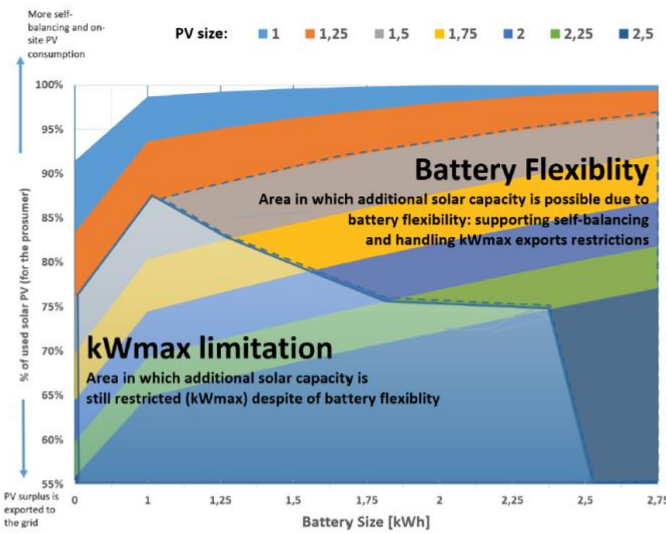

Figure 2: Value of battery flexibility (UK)

As for the case in the United kingdom, results were mainly a function on quantifying the energy arbitrage gains from ToU price. For a typical UK house (annual demand of electricity: 3.8 MWh, no PV considered), three battery sizes were tested: 1.4kWh, 2.9kWh, and 4.3kWh which produced cost savings in the magnitude of 7%, 11% and 15% compared to not having the battery in the house. For the cases in Bulgaria, Germany and Spain, we have computed preliminary results that are showing a similar outcome but with more revenue from solar production.

Conclusions

Our studies show that distributed energy systems have great economic potential, especially as PV and battery costs are expected to decrease. The value of battery flexibility differs between different cases, depending on investment costs and energy prices in the relevant country. We observed that for countries with electricity based heating systems battery storage will find a greater match since electricity consumption will be large. This is the case for Norway, although low electricity prices and low solar production in the lengty winter period might diminish the deployment of batteries. This is a contrast to our results in the UK case in which high fluctuations in electricity prices produces interesting cost savings despite of also low PV potentials.

References

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