The role of batteries in the profitability of smart-grid business models

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i. Overview

During the last decades renewable energy sources have become an integral part of the energy policy due to several reasons, including increasing retail prices, climate change and depletion of fossil fuels. Perhaps the most interesting aspect is the energy democratization; Photovoltaics (PV), wind turbines and other technologies are adopted not only by large-scale generators, but consumers as well. In the latter case, home owners, Small-medium enterprises and cooperatives become prosumers, producing energy locally and deciding how much to consume or export to the grid.

Previous literature has found that traditional governmental energy financial support schemes (e.g., Feed-in tariffs, defining the fixed income of producers for each KWh injected to the grid for a rather long period such as 20 years) have had great impact on the adoption of renewable technologies by consumers around the globe. In general, the Prosumer business model becomes profitable in cases where a) the benefits from self-consumption are very important, such as in countries with high retail prices (e.g., Germany), for large buildings where demand usually exceeds production (such as offices), smaller buildings with temporal overlap of production and load curves (such as residents with pensioners), or flexible loads (such as smart homes) and b) generation potential is significant (e.g., in southern EU countries with high solar irradiation).

In this paper we will focus on the effects of storage technologies on the economic viability of the grid-connected prosumer Business Model (BM) and other associated business models, such as RESCO (Renewable Energy Service Company) /Aggregator, for several European countries, under varying levels of governmental financial support.

ii. Methodological approach

We developed a simulator of a (hypothetical) prosumer's decisions regarding energy production, consumption, battery charge/ discharge and import/injection that takes into account several factors, which include, but are not limited to:

- locality, especially for determining generation capacity, load patterns and considering the financial regime (fixed/dynamic retail prices, injection prices, net metering presence, etc.);
- agreements with other market actors like DSOs, RESCOs/Aggregators;
- technology (such as batteries and smart controllers for participating in Automated Demand-Response campaigns),
- residents' habits in terms of absence hours, price elasticity or willingness to join Demand-Response campaigns.

The simulator is very fine-grained (e.g., works on quarter-hour time-scales for a complete year), powerful and extensible. A key feature of the simulator is a repository of (currently) 54 separate prosumer states, which depend on the local production level, consumption, battery state-of-charge, arbitrage between retail prices, peak/off-peak period and presence of DR campaigns, etc. At any point in time the prosumer will be in one of those states based on the policy to be followed (e.g., if retail prices are currently higher than injection prices then prioritise local consumption, use excess production for charging battery and inject any remaining production to the system). There are already 54 different states supported (note that the number of states need not be a power of 2 as some states would never take place) and this allows us not only to make sure that energy balance always holds, but also to derive, in the future, interesting statistics on how frequently a modelled prosumer visits a particular state, state transition probabilities, etc.

In order to run the prosumer simulator, we used data inputs on solar production, load curves and retail prices for each European country, namely Belgium, Greece, Germany, Italy, Spain and UK from publicly-available data sources (in most cases the ENTSO-E Transparency Platform). Furthermore, we defined a set of random variables for mimicking a wide range of events, such as grid issues to be resolved using ADR campaigns, the acceptance of a prosumer to shift some load to other time slots, inverter availability, etc. The prosumer simulator outputs, such as annual self-consumption, injected energy, imported energy, flexibility provided, etc. were fed into the Nobel Grid Business Model evaluation tool[1] for studying under what circumstances the grid-connected prosumer business model is financially attractive, or additional support from other business entities (such as RESCOs/Aggregators) is required.

iii. Results

We modelled the following 3 business models: a) grid-connected prosumer b) grid-connected prosumer with battery and c) grid-connected prosumer with battery and ADR presence. Furthermore, we evaluated 3 variations of the initial ones where RESCOs finance the infrastructure (PV panels, inverter and where appropriate the battery) in exchange for obtaining the revenues from energy injected to the grid. These variations make sense because RESCOs usually enjoy economies of scale.

We have assumed that a rooftop PV panel of 3.6Kwp is installed in all six locations, which costs € 5400 (including the inverter). The battery has a capacity of 5.4 KWh and costs € 2100. In the cases where a RESCO pays for the equipment, the

[1] http://nobelgrid.eu/business-model-evaluation/

upfront cost is reduced by 25%. The retail prices (€/KWh) are as follows 0.2745 in Antwerp (BE), 0.1723 in Attica (GR), 0.2977 in Berlin (DE), 0.22345 in Valencia (ES), 0.23765 in Terni (IT) and 0.1891 in Manchester (UK). On top of the retail price consumers are charged a VAT of 15%. Regarding the prosumers' remuneration scheme we considered two options: a low Feed-In Tariff of 0.069 €c/KWh and Net-Metering with annual billing period. The former represents a low injection price that was announced in Germany, while the latter reflects a high injection price (which equals retail price) that also makes users indifferent between storing locally produced to a battery and injecting to the grid. In case of an ADR campaign, the entity requesting flexibility pays 0.4 €/KWh, which is evenly shared among the ESCO organizing the campaign and the prosumers that actually deliver the flexibility. We assume that flexibility is always provided (e.g., prosumers don't override RESCO decisions about temperature set points) and thus no penalties apply, while comfort is preserved by shifting consumption to other periods. A consequence of the latter assumption is that total load is unaffected (no energy efficiency). Finally, prosumers pay a fixed annual amount of € 120 to RESCO for receiving consumption recommendations.

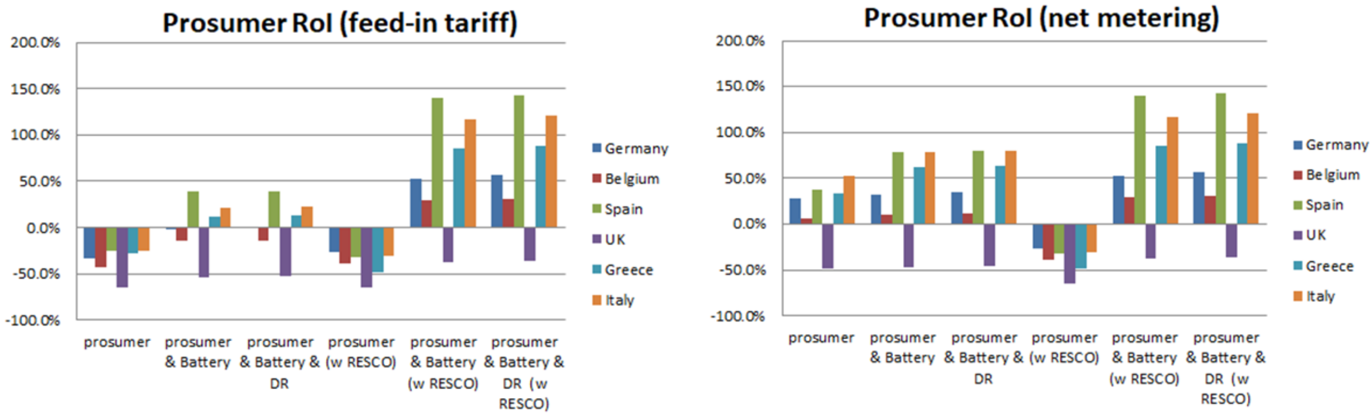

Figure 1: The Return on Investment of the Prosumer business model in case of low feed-in-tariff regime and net metering

From the left figure above we can see that, in case of low governmental support, the prosumer business model is not viable in any of the areas explored. Adding a battery renders the business model attractive in countries with high production capability, namely Spain, Greece and Italy (with payback period in about 12, 17 and 15 years respectively). Responding to ADR campaigns (about 600 events in total annually, or 1.7% of all time slots) has a marginal positive effect. Finally, even though RESCO's financing of equipment cannot offset the effect of low FIT's, adding a battery greatly improves economic performance for the prosumer. From the figure on the right hand side, we see that net metering renders attractive the business model of the prosumer in all areas but UK (where prices are low and at the same time the production is low). On the other hand, high retail prices in Germany result in positive outlook. Adding a storage system improves economic performance further in all 5 areas, but most in southern EU.

The RESCO's economic performance in terms of Return-On-Investment (RoI) appears in the following figures. In the case of low FIT (left figure), the plain prosumer business model is lucrative in the southern countries. Assuming that the RESCO cannot inject part of the stored load, the addition of a battery has a negative impact on the injected volume and consequently on its revenues. In the net metering case (right figure), the plain prosumer is viable in all regions, while adding a battery is less attractive (or in the case of UK not attractive at all).

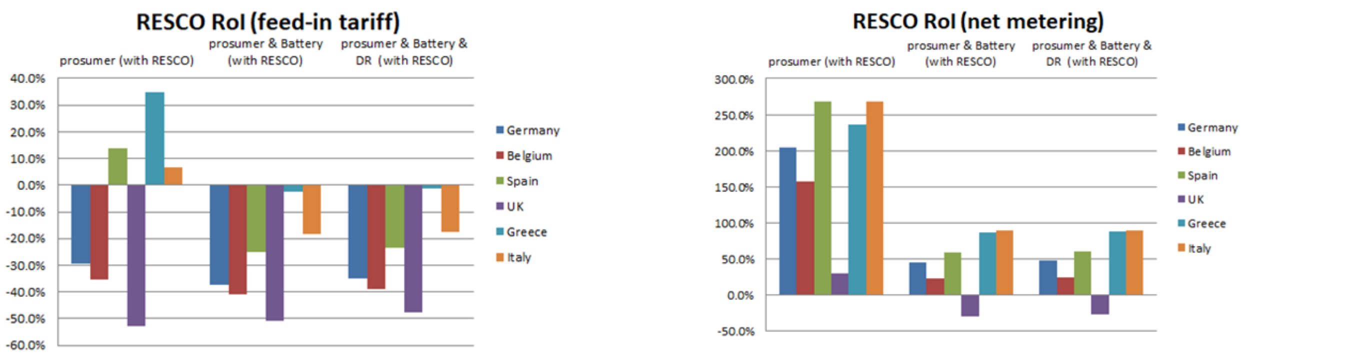

Figure 2: The Return on Investment of the RESCO business model in case of low feed-in-tariff regime and net metering

iv. Discussion and conclusions

Based on our analysis we see that low governmental financial support can be overcome when production is combined with storage systems (e.g., battery) in countries with high solar irradiation (e.g., southern EU countries), or high retail prices (like Germany). These prosumers can improve their profitability by partnering with RESCOs, even though the latter would need to sell part of its capacity to the grid in order to invest in batteries. In the full version of the paper we will perform sensitivity analysis in order to identify cases where prosumage is attractive.