Assessment of regulatory frameworks to define community energy storage sharing mechanisms

David Ribó-Pérez* (david.ribo@iie.upv.es),

Álvaro Manso-Burgos,

Tomás Gómez-Navarro

Overview

Including decentralised energy storage technologies can facilitate the integration of distributed renewable energy sources, empower electricity consumers and positively impact the grid. Renewable energy sources are characterised by intermittency depending on natural factors like irradiation or wind prevalence. This intermittency causes the price of energy to fluctuate over time and even results in excess power being injected into the system. Energy storage systems can store surplus power from renewables to inject during deficits. Hence, ramping and providing valuable arbitrage are services that storage can offer to the energy system (Elshurafa, 2020). Storage systems can help meet the system's demands, maintain service quality, and reduce network peaks while incorporating more significant shares of renewable energy sources (Prakash et al., 2022).

Recent developments in the energy system indicate the rise of storage systems, especially at the utility scale and in single households (EASE, 2023). Nonetheless, renewable energy communities still do not incorporate storage systems even though they can reduce the amount of energy interchanged with the grid and reduce the power peak demand, lowering the bills. We believe regulatory frameworks must be developed to define the sharing mechanisms in Community Energy Storage (CES). This enabling framework can benefit both the energy communities and the entire energy system by reducing congestion in distribution networks, fostering investment and facilitating consumer participation.

However, the European Union still needs to define a clear regulatory framework for the deployment of CES (Gährs and Knoefel, 2020; Tejada-Arango et al., 2019). The recast of the Electricity Directive in 2019 addressed several barriers that hindered energy storage investment and innovation, "namely lack of definition, unclear ownership and operation rules, double charges and inadequate legal framework for benefit stacking" (Parra and Mauger, 2022). This recast of the Directive differentiates and defines energy storage rather than being a unit of energy consumption or production. Nevertheless, it does not clarify how the stored energy can be shared among the users, leading to a lack of certainty in the economic value of these systems for the energy communities. Defining how the energy stored can be shared would push the deployment of CES.

The development of energy communities in Spain after the recast of the Renewable Resources Directive in 2018 is an example of the impact of a regulatory framework on the deployment of innovative systems. Sharing the distributed energy resources within renewable energy communities is essential to shift towards renewable energy successfully. Some reasons are that roofs can be fully utilised to generate solar energy and make projects more accessible to a broader population. Encouraging participation in these communities can also make them more attractive to potential members (Brummer, 2018). However, their deployment took off in Spain only when the regulatory framework was created. CES systems will be beneficial under proper regulatory frameworks (He et al., 2023; Parra and Mauger, 2022).

Methods

This study aims to evaluate the benefit of different sharing mechanisms for stored energy. To do that, we employ a mathematical model to optimise the operation of a renewable energy community with energy storage systems under different frameworks. We apply this model to a case study in Valencia, a compact Mediterranean city in Spain. The system consists of residential loads, a solar installation as the distributed energy source, and a community energy storage system based on Li-ion batteries backed by the power grid.

This research compares three strategies that can regulate CES energy sharing: static, variable and dynamic allocation coefficients. The main difference between the three strategies is how the energy is allocated to the different consumption points once the storage system releases it. Depending on the strategy employed, the energy community will have a different impact on the energy system despite these being accounting balances on the bill. The reason is that the stored energy will be deployed differently depending on the accounting balances the energy community can do.

Results

If the energy community uses static coefficients, the power distributed from the battery system is shared among the consumption points at constant rates regardless of the current demand. This strategy can lead to suboptimal situations where a consumption point receives more power than demanded and has to dump the excess into the energy system while other consumption points are still in deficit after receiving the energy stored. The solution is to find the rates that perform best on average during the year. The variable coefficients imply that the rates can change over time, but they must be defined ex-ante and do not respond to the actual demand. This strategy also relies on average optimal rates, but we can define some daily profiles to accommodate the demand sharing. This study presents eight daily consumption profiles: one for each season, divided into weekdays and weekends. Finally, dynamic coefficients are calculated ex-post the hour of consumption. The battery systems share or consume energy considering the hourly deficit in each consumption point, but also the system signals (prices and congestion) and excess generation. An ex-post calculation of the allocation coefficients can generate a better use of the technology.

Different indicators are used to determine the impact of each strategy on the renewable energy community and the system. To assess the effect on the energy community, we will use economic indicators such as the net present value of each consumption point throughout the project and their internal rate of return. On the other hand, we measure the effect on the energy system by comparing network demand peaks. Economically, we consider income losses concerning the reduction in the contracted power term.

Conclusions

This study will help policymakers to define the regulatory framework of CES. It proposes three different sharing mechanisms for stored energy and evaluates the economic and technical implications for renewable energy communities and the energy system. This assessment sheds light on an aspect of CES that remains unclear and whose definition should help to promote their deployment. Without a definition that allows CES to show its real potential and improve the performance of and Energy Community, CES will have difficulties to play a role in them.

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