



FPS Economy, S.M.E.s, Self-employed and Energy

ECOFLEX

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D6.1 Implementation of flexibility ecosystem

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Abstract for dissemination (PU)

This report examines the integration of small, distributed energy assets—such as rooftop solar panels, residential batteries, and electric vehicles—into energy flexibility markets. It focuses on the collaboration between Flexcity, which provides market access, and VUB, which manages the energy management system (EMS). The document analyses two balancing markets: (i) the imbalance market and (ii) the automatic Frequency Restoration Reserve (aFRR) market. The report concludes that while low-voltage flexibility assets have significant potential, bureaucratic, technical, and market barriers remain. Centralised platforms and regulatory improvements are recommended to facilitate broader participation and efficient settlement, positioning low-voltage flexibility as a crucial tool for future grid management

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List of abbreviations

aFRR	Automatic Frequency Restoration Reserve
BRP	Balance Responsible Provider
BSP	Balancing Service Provider
DSO	Distribution System Operator
EMS	Energy Management System
MTU	Market Time Unit
TSO	Transmission System Operation

1. Introduction

The proliferation of small, distributed assets such as rooftop solar panels, residential batteries, and electric vehicles is a growing trend in the energy sector. These assets offer flexibility in terms of energy production and consumption, enabling individuals and communities to: generate, store, use, and most importantly for the framework of this project also trade their power. However, the lack of centralized control and market access can pose significant challenges. Without a unified system to manage and coordinate these distributed assets, it can be difficult to reliably provide the flexibility when necessary. Additionally, market knowledge of the different markets and requirements to participate can pose a strong barrier to entry for any asset owner interested.

This deliverable looks at two different markets where the algorithm created by VUB (cf. WP4 and WP5) will provide flexibility to the system. The first system implemented is discussed, then for each balancing market, the requirements as well as the pros and cons are presented, and finally, recommendations for future improvements will also be presented.

2. Implementation overview

As Flexcity's role focuses on giving market entry to energy management systems (EMS), all responsibility revolving around steering and determining the available flexibility was fully given to the EMS. The diagram below shows the interaction between Flexcity and the VUB's EMS for the case of imbalance steering, which will be discussed in more detail in the section below.

The data flows as such: Flexcity, as a balancing service provider (BSP), analyses the market data such that it can provide a forecast of what the future prices will be. These predicted prices are thereafter shared with the EMS, which in turn will use them to determine whether or not it should take any action. The decision taken by the EMS is then communicated to Flexcity, which will then be used for settlement.

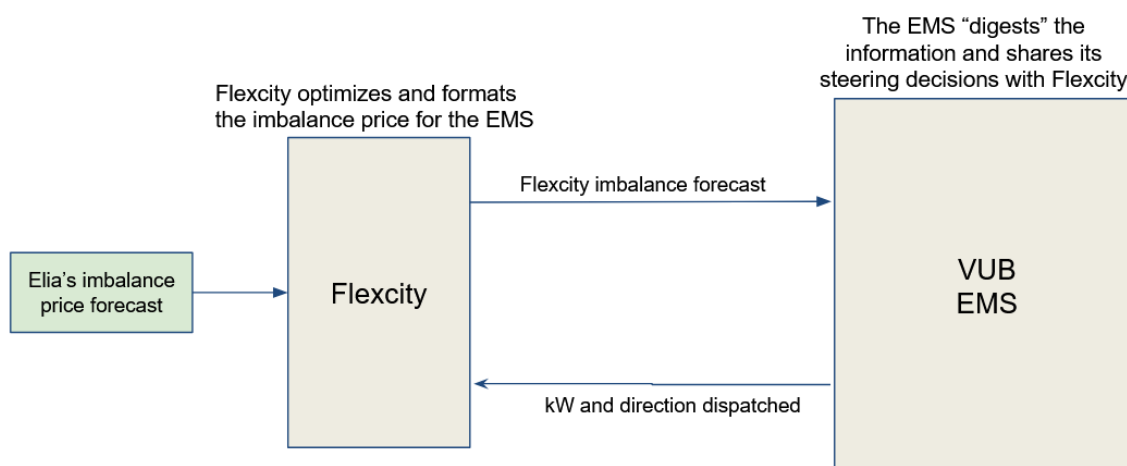


Figure 1. Data flow between Flexcity and VUB's EMS

This implementation presents great advantages such as:

- The BSP, in this case Flexcity, can fully focus on the market analysis and making sure that the EMS is provided with the most financially interesting offers of providing flexibility;
- The VUB take responsibility of the development and maintenance of the EMS;
- Both the BSP and the EMS (VUB) do not need to know each other's operating code, which creates no proprietary conflict.

As it will be seen in the next sections, depending on the market, the EMS needs to decide whether to participate either at the last minute before dispatching or 25 minutes before market time unit (MTU).

For more details about the communication between Flexcity and the GEP EMS, interested readers are referred the ECOFLEX deliverable “*D4.1 - Report on different smart charging management structure for electric vehicles*”.

3. Imbalance market

3.1. What is the imbalance?

Imbalance is unique compared to all other markets, such as the automatic frequency restoration reserve (aFRR). This is mostly due to the characteristics that no bids are required to be able to dispatch energy. Where imbalance refers to the energy parity in the system. If the imbalance is positive, then it means that there is too little energy in the system, and vice versa when it is negative. Therefore, a positive imbalance is linked to a positive imbalance price.

If an asset would produce when the imbalance price is positive then then the transmission system operator (TSO) would remunerate this asset for helping the grid to restore its equilibrium through its flexibility. The equivalent for an asset that consume is then for it to reduce its consumption which would result in more energy being available in the system.

The TSO can determine whether an asset has increased production based on its balancing responsible party's (BRP) nomination. This nomination represents the baseline that the asset was supposed to follow. For an asset that produces, it would represent the energy that has been sold onto the electricity market. To this end, if an asset deviates in the direction that solves the imbalance of the system, then the TSO will remunerate the BRP for it. However, in case the deviation worsens the system imbalance even more, then the BRP will be penalised.

3.2. Imbalance implementation

In the case study of ECOFLEX, the imbalance market was theoretically implemented, meaning that the EMS was able to respond to imbalance prices and change from its baseline. As highlighted in the ECOFLEX deliverables D4.1 and D5.1 and D5.2, the developed EMSs are able to provide all the data necessary to compute settlement. Nonetheless, a few aspects need to be highlighted about this balancing market and its implementation in the context of ECOFLEX.

As the imbalance market is fully based on the deviation of a BRP nomination, *no minimum volume is required* to be able to get a remuneration. This is not the case for other balancing markets like aFRR, where a minimum of 1 MW is needed to participate (more details in the next section). This makes it very important for a market participant like Flexcity, as qualifying

multiple small assets to the TSO can be work and time-consuming, and thus drive market participants away.

Additionally, the participation to the imbalance market is fully voluntary and does not require a prior commitment to the TSO, meaning that the EMS can decide to dispatch or not at the last minute. This creates fewer constraints for the optimization algorithm.

On the other hand, all the cashflow is centralized around the BRP which can create difficulties with settlement. Depending on the asset, the BRP may not recognise a deviation from the baseline and thus deny the remuneration to an asset. This can become particularly more complex in the context of assets such as electric vehicles (EV), as they do not have a planned baseline (or deviate from the input they provided in a user interface – such as the one developed in deliverable “D4.2: Front end applications for charge scheduling”). Small assets are also subject to not having one BRP but rather two: i.e. one for injection and one for consumption, making it harder to implement imbalance steering as two agreements are needed.

Last mentioned hindered the implementation of imbalance steering on the Green Energy Park (GEP) batteries – one of ECOFLEX’s pilot sites. Since, GEP has a contract with two BRPs and only the BRP responsible for injection was willing to allow the batteries to do imbalance steering.

The graph below (Figure 2.) shows how Flexcity used the GEP batteries to inject power into the grid when the imbalance price was positive (i.e. lack of energy in the system).

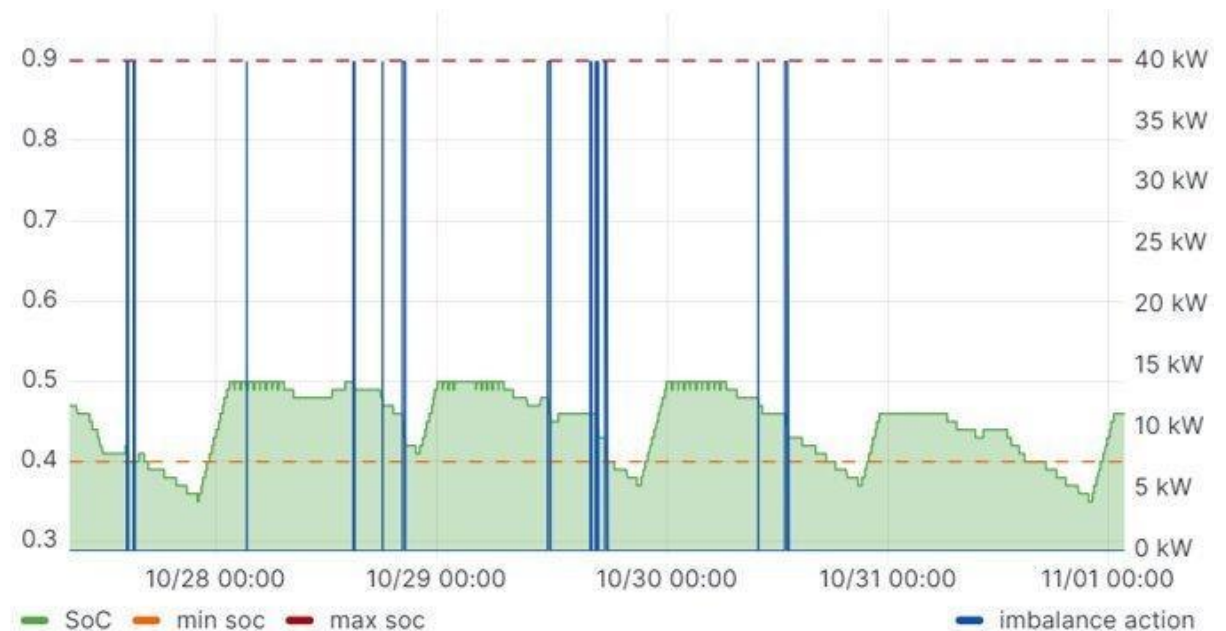


Figure 2. Imbalance activation with GEP battery

4. aFRR market

4.1. What is the aFRR market?

Automatic Frequency Restoration Response, or aFRR, is a service contracted by the TSO to balance frequency fluctuation in the grid. The TSO has an aFRR energy auction in place for each quarter hour of the day. BSPs can place bids that get ranked in a merit order manner (from cheapest to the most expensive bid). To this end, the TSO activates based on how much volume is required, effectively maximizing the welfare.

BSPs can also gain additional revenue through capacity auctions. If a BSP is selected in one of these auctions, it is then bound to populate the aFRR energy auctions with bids with the amount of volume that was contracted at the auction. This is a way for the TSO to make sure that for each aFRR energy auction, there are always bids present and therefore a way to restabilize the grid.

In order for an asset to be able to participate in the aFRR market, it needs to fulfill two requirements:

- Firstly, it needs to be associated with a BSP. The BSP will act as the market counterparty that will place bids on its behalf as well as receive all remuneration for the aFRR activations.
- Secondly, an opt-out agreement between the BSP and the BRP must be made. The opt-out agreement guarantees that the BRP transfers all remuneration of the aFRR-activation to the BSP. Figure 3. demonstrates the settlement flow between each party.

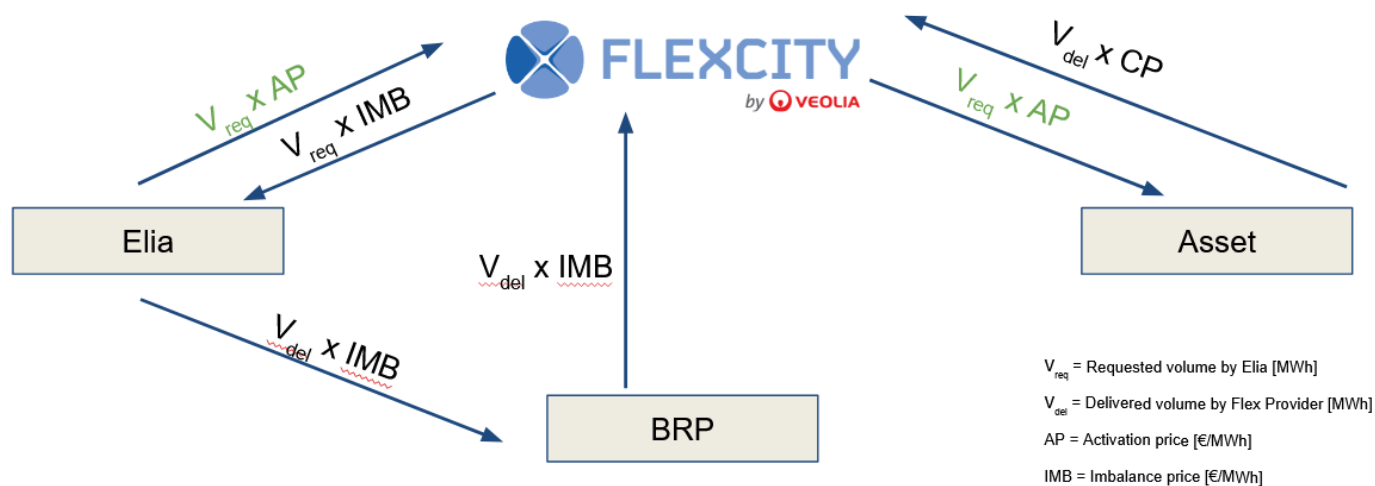


Figure 3. Cashflow between the TSO, BSP, and asset owner

4.2. Implementation aFRR market

The opt-out agreement was a first blocking barrier when implementing the aFRR product to the two batteries at GEP. As explained in the Imbalance market section, since the GEP has two BRPs, one for injection and one for consumption and the BRP responsible for consumption was unwilling to sign an opt-out agreement. The alternative would be for GEP to get a pass-through contract with the BRP, meaning that the park would be exposed to any imbalance deviation. However, this is not a financially interesting option, for a site that does not have predictable consumption. Because of this first restriction, the batteries were *able to only do aFRR in the upwards direction* (injection into the grid). This difficulty is likely to be faced on other occasions as BRP may not be willing to sign an opt-out agreement with entities that they see as possible competitors.

In addition to legal hurdles, market designs can also create complexity in the implementation. The Belgian aFRR market (and likewise across Europe) has the requirement that *all bids have a minimum size of 1 MW*. While this is usually not a major issue for BSP as their portfolio is mostly based on large industrials or power plants, for small assets such as EV charging points or the GEP batteries, this is a strong limiting factor. The GEP batteries at disposal were below 1 MW, hence a BRP (such as Flexcity) could never valorize them individually. An alternative to bypass this limitation is to aggregate the batteries' volume with other aFRR bids (of the BRP) to form a full 1 MW bid. For example, the GEP battery at disposal has a volume of 300 kW, and Flexcity has a client that has 700 kW "left over". Then the two volumes can be aggregated into a single bid that is compliant with the minimum size.

This solution was implemented, but the bid has not been activated. The lack of activation can be linked to a few reasons:

- Flexcity does not have particularly abundant "left-over" capacity, meaning that the battery volume cannot be aggregated into a bid for every quarter-hour, reducing the possibility of activation.
- When aggregating the kW of the battery, the price will be set by the other asset forming the bid. This means that if the battery is aggregated into a bid with a high price, it is unlikely to be activated because of the merit order type system.
- aFRR has become a more competitive market since the entry into the pan-European platform PICASSO¹. This platform connects aFRR bids from multiple countries, allowing for a TSO from a country (e.g. Belgium) to restore the frequency instability from another country (e.g. Netherlands). This resulted in cheaper prices but a more competitive market making it harder to get an activation for the reasons explained above.

Another issue that comes with the addition of small-sized batteries into a portfolio comes with respect to settlement. Whenever an asset is activated, the owner needs to be remunerated based on the amount of energy that has been activated. As the batteries are of small-size, the remuneration is not interesting until a substantial amount of small batteries are added to the portfolio. This means that for each activation, the BSP must compute exactly how much energy was activated by each asset individually, which can be lengthy and prone to errors. Especially when the activated volumes are on the order of magnitude of the kW.

Error can be caused by possible miss or under activation of the batteries, which can happen if there is a communication error between the EMS and the BSP.

¹ https://www.entsoe.eu/network_codes/eb/picasso/

A centralized platform such as the ‘Universal Flexibility Platform’ or UFP as proposed in ECOFLEX, can ease the blockage faced by a BSP when dealing with such asset sizes.

As this report is being written, the battery was not activated and from already historical monitoring of Flexcity’s portfolio, it seems to be very unlikely. On the other hand, a way to test the low-voltage battery’s readiness for an aFRR activation, is to send what is called a ‘prequalification test’. This is a test that Flexcity usually does to qualify new capacity into its portfolio. The TSO sends an activation signal to the BSP that needs to follow it with its portfolio. This ensures that the BSP portfolio is capable of following a setpoint for frequency stabilization. The prequalification signal encompasses the following characteristics:

- The capacity required for it is 1 MW;
- The signal can be bidirectional or unidirectional;
- Every 4 seconds a setpoint is sent to the BSP;
- There can be a maximum of 15% error margin.

As the battery does not actually follow a real activation signal it was chosen to send a bidirectional prequalification signal. The results of how the battery performed during these test is showcased in Figure 4.

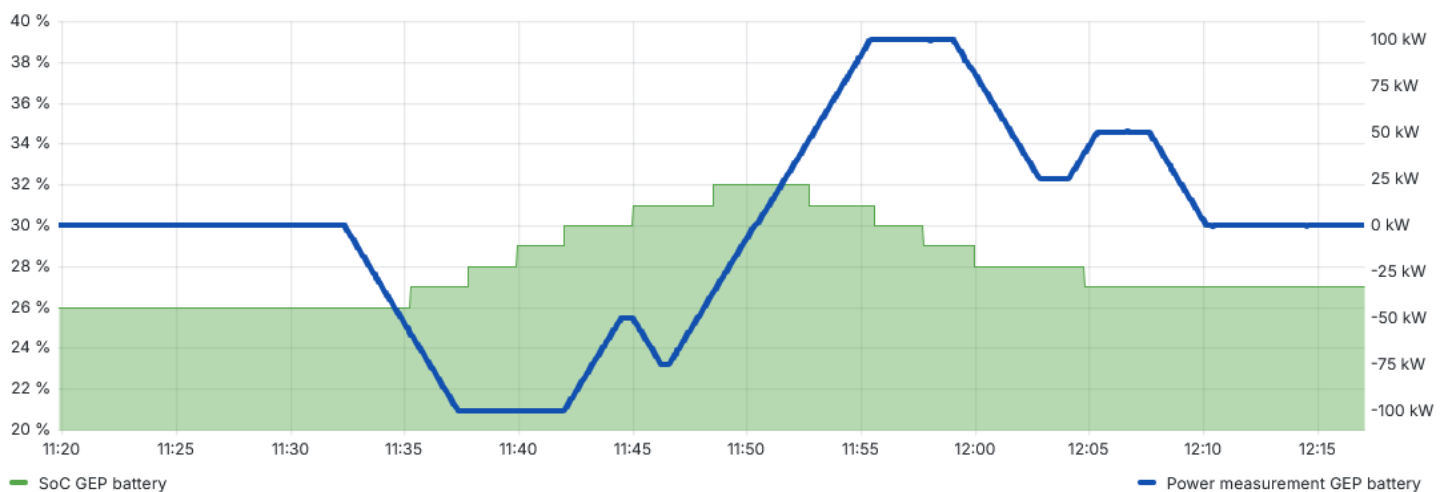


Figure 4. Power and SoC measurement of the GEP battery during a prequalification signal activation

5. Conclusions

Although the growing recognition of the potential of low-voltage flexibility, there are still some challenges ahead for its implementation, both at the bureaucratic level as well as at the bidding stage and settlement.

The main bureaucratic issue faced within this project, specifically in the implementation, was getting an opt-out agreement. This is particularly difficult and lengthy when operating with low-voltage assets, as it is likely that two suppliers/BRPs may be involved, meaning that an opt-out agreement needs to be reached with both parties which can prove to not be straightforward as shown. Even in more accessible markets such as the imbalance market, an agreement with the BRP would still be needed for settlement reasons which can block the whole implementation.

Other difficulties were explained, such as measurement and settlements where having a large fleet of small assets can reveal to be time consuming and prone to error(s), making it possibly less interesting for a BSP to pursue as asset type rather than opting for assets connected at the medium/high voltage. This could be greatly simplified with a platform centralizing all the information as proposed within this project, i.e. the Universal Flexibility Platform (cf. Deliverable D6.2).

Overall, low-voltage flexibility is still facing some market barriers. Nevertheless, TSOs and distribution system operators (DSOs) are showing an increasing interest in facilitating and incentivising its development. With the understanding of flexibility becoming more popular, combined with the technological advancements, low-voltage flexibility is very likely to become a key necessary tool in grid management in the coming years.