Miłosz KRYSIK, Krzysztof PIOTROWSKI
IHP – Leibniz-Institut für innovative Mikroelektronik, Im Technologiepark 25
15236 Frankfurt (Oder), Germany

ENERGY FLEXIBILITY AS AN EXAMPLE FOR A COMPLEX DATA EXCHANGE SYSTEM

The increase of Renewable Energy Sources (RES) in the energy grid is crucial for the energy transition. Their proper integration and control allow achieving the strategic goals as well as coping with their dynamics by exploiting the flexibility available in energy system. This work presents the study on energy flexibility within the context of measurement and control, considering the relations between stakeholders and the Data Space approach.

ELASTYCZNOŚĆ ENERGETYCZNA JAKO PRZYKŁAD ZŁOŻONEGO SYSTEMU WYMIANY DANYCH

Rosnąca liczba Odnawialnych Źródeł Energii (OZE) w sieci energetycznej ma kluczowe znaczenie dla transformacji energetycznej. Ich właściwa integracja i sterowanie pozwalają osiągnąć cele strategiczne, a także radzić sobie z ich dynamiką poprzez wykorzystanie elastyczności dostępnej w systemie energetycznym. Niniejsza praca przedstawia studium nad elastycznością energetyczną w kontekście pomiarów i kontroli, z uwzględnieniem relacji między interesariuszami i podejścia opartego na przestrzeni danych (Data Space).

1. INTRODUCTION

Power grid systems are in a phase of transition to a modern system with an increasing number of Distributed Energy Resources (DER) located predominantly at the distribution level [1]. The grid that is highly penetrated by the variable sources entails problems like congestion, voltage violations, and uncertainty of supply. However, distributed generation carries undeniable advantages like increased flexibility in the system, enabling electrification of sectors like heat and transport, producing clean energy, applying decentralized management, etc.

Management of flexibility is mandatory to enhance investments in DERs and customer engagement, in addition to overcoming grid balancing problems like power quality or congestion [2]. EU suggests a market-based approach to handle the flexibility [4]. As a result of the fact that most of the RES are installed locally, at the distribution level, Local Flexibility Market (LFM) is an emerging idea.

Numerous projects demonstrate advancements in flexibility management [6]. ENERA, led by EPEX Spot, addresses network congestion and renewable energy curtailment in Germany. GOPACS in the Netherlands tackles congestion across voltage levels, enabling redispatch flexibility. Picloflex in the UK develops a marketplace for standardized flexibility products, cutting grid reinforcement expenses for DSOs. Internationally, Nodes seeks to enhance grid operation by procuring.

There are two ways of quantifying flexibility services, namely baselining and capacity limitation (CL). The first one is the calculated pattern of the future consumption treated as a reference, deviations above the threshold from the baseline triggers the flexibility services [1]. There are a wide range of methods to calculate baseline, however, a lot of them are criticized [2]. Due to that, CL was proposed [2]. It keeps the consumption or generation below or above a certain limit but is dependent on truthful declaration of assets by flexibility service providers (FSPs) and requires modification of market methods.

The objectives of this paper are to explore the stakeholders involved in the flexibility market, identify barriers and challenges, analyse interactions between stakeholders, examine data exchange processes, and propose leveraging data for enhanced flexibility trading on Local Flexibility Markets. Additionally, the paper aims to highlight the importance of advanced analytics, data-driven decision-making, and the deployment of integrated digital platforms with IoT, edge computing, and cloud technologies to optimize flexibility trading operations.

2. FLEXIBILITY TRADING PROCESS ON LOCAL MARKET

2.1. Measuring flexibility

To provide the flexibility products on the market, first, the metric of flexibility resources is needed. The comprehensive and suitable way for multiple scenarios and ancillary services was described in [5]. The attributes of the flexibility are power and energy capacity, direction, ramping, service duration, reaction duration, recovery duration, trigger signal, rebound effect and are visualized in Fig. 1.

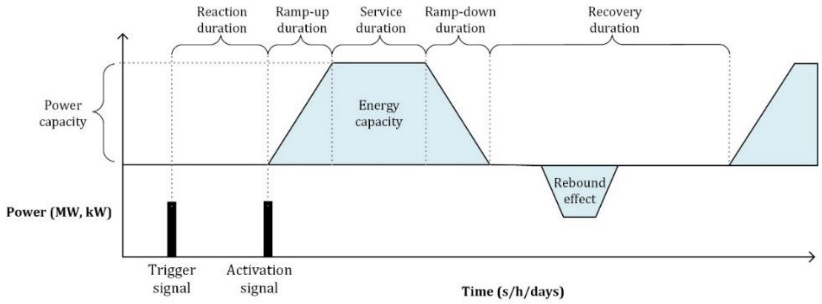

Fig. 1. Characteristics of the flexiblity
Rys. 1. Charakterystyka elastyczności

2.2. Stakeholders

There are many stakeholders involved in the flexibility market. In the centre and focal role is the prosumer. On its own, it might be unable to participate in the market, because of too small a possible offer to bid and cumbersome constant monitoring of the market. Multiple prosumers are gathered together under Aggregator, which represents the cluster of prosumers on multiple markets for instance on LFM offering flexibility and ancillary services. Larger prosumers can enter the market themselves. All of the participants offering flexibility are called Flexibility Service Providers (FSPs). On the other side of the LFM are Distributed System Operator (DSO) responsible for delivering energy to consumers with appropriate quality and assuring stability in the distribution level on the grid and ensuring a balance between supply and demand. To achieve this, buying flexibility from FSPs is highly desirable. DSO could also outsource balancing the grid to Balancing Responsible Parties (BRPs) who might be also interested in buying flexibility from FSPs. Apart from the market participants, the platform of the market should be governed by the Market Operator (MO). There are different approaches in the literature, of the governor of the MO platform, like managed by Aggregator, DSO, or BRP. However, the market mechanism is the most secure, when the owner is an independent entity.

2.3. Interactions between stakeholders

To successfully provide flexibility to the desired place, the comprehensive data flow shown in Fig. 2 must be completed. Effective stakeholder interactions rely heavily on the exchange of data. Establishing collaboration in data sharing is essential to achieving objectives such as grid reliability and efficiency, while simultaneously addressing potential conflicts. First, the Flexibility Assets (FA) must provide their measurement data to the energy management system of the prosumers' building. Prosumers with access to the measurement data can decide how much flexibility they can provide in a given time horizon. This data is then forwarded to the contracted Aggregator. Here is the most vulnerable and the most controversial part of data management. The question arises as to whether the prosumers should be extra remunerated for sharing their data. Aggregators collect all provided data and create the flexibility offered to the market. On the other side of the market, there are stakeholders, which are consuming flexibility. First, DSOs receive grid-metered values from their own SCADA system. By processing this data, they can detect undesired grid behaviours or forecast them. DSO, BRP are creating flexibility requests for the market. MO manages operations like bidding, clearing, and settlement.

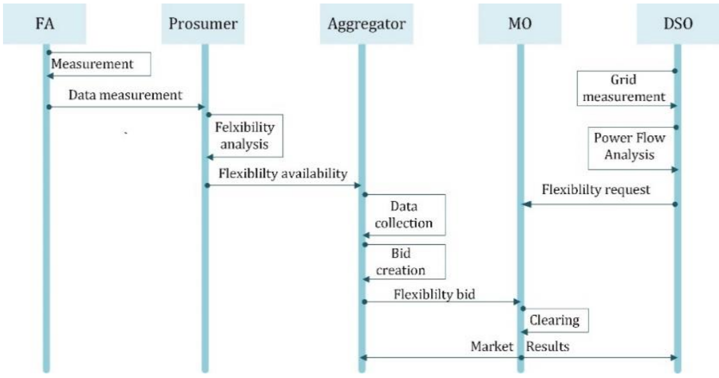

Fig. 2. Market process of flexibility
Rys. 2. Rynkowy proces elastyczności

2.4. Data exchange

The previous paragraph presented the importance of various data exchanges between stakeholders on different levels. Three main types of data are involved within energy flexibility in the context of measurement and control, namely measurements, market data and operational data. The measurement data includes real-time data on energy consumption, generation, and grid conditions. The majority of this data is owned by the prosumer or DSO. In the case of prosumers, there is a huge concern about privacy and security in sharing this data, however, Aggregators can benefit highly from access to this data to balance and optimize their flexible portfolio and bid more attractive offers to the market. DSOs hold grid measurement data, that is used to forecast congestions and unbalances in the grid. This data similarly can be utilized by other stakeholders like aggregators or prosumers to either optimize the portfolio or optimize the sizing of the new investments.

Market data consists of current and historical information about market prices, regulatory frameworks, and demand forecasts. Prices for energy, flexibility, and other ancillary services can optimize the decision-making process of both participating in the market, as well as creating the bids. Aggregators can enhance revenue opportunities and DSOs can improve their forecasting and calculate the sense and the return of investments. Transparent data can also enable early detection of inc-dec gaming or other market strategic behaviours.

Finally, the operational data encompasses all the data related to segments of execution of the transactions i.e., bids, settlement, activation, and clearing. The operational data benefits stakeholders in flexibility markets by enabling optimized resource allocation, proactive grid and market management.

2.5. Barriers, challenges, conflicts and the need of digitalization

There are economic, technical, social and legal barriers to participating in flexibility trading [7]. The economic barriers concern aspects related to monetizing data, investment development, and business models. The societal barriers are resistance or lack of awareness about the benefits of such markets, that keep from the participation. Moreover, concerns about data privacy and cybersecurity are relevant for the prosumers. The legal barriers related to regulatory frameworks to ensure fair participation and compliance can be complex, requiring clear guidelines and policies. In addition, legal frameworks must navigate the complexities of data ownership, access rights, and regulatory compliance, ensuring transparency and protection. The technical barriers are linked to the necessary infrastructure, like smart meters and dynamic tariffs. In addition, some challenges exist in all systems connected to data spaces, like data interoperability, standardization, harmonization, data quality, and visualization. [3].

Data conflicts between stakeholders in flexibility trading often arise due to differing priorities, objectives, and concerns regarding data ownership, access, and utilization. One of the possible conflicts is data shared between prosumers and Aggregators. Prosumers may prioritize privacy and data security and can fear unauthorized access to their consumption patterns and personal information. On the other hand, Aggregators may emphasize the need for comprehensive data access to optimize flexible resources and facilitate efficient trading. The data could be further processed by MO. DSOs may have concerns about sharing sensitive grid data with MO due to regulatory compliance, while MO require access to this data for effective market coordination. MO require timely and accurate data from Aggregators to optimize market clearing and ensure efficient resource allocation. Conflicts may arise if Aggregators fail to provide the necessary data or if there are discrepancies between the data provided by Aggregators and other market participants. Aggregators rely on market data and price signals from MO to optimize their trading strategies and maximize revenue. Conflicts may occur if MO impose restrictions on data access or if there are concerns about the fairness or transparency of market rules and mechanisms.

3. LEVERAGING DATA FOR ENHANCED FLEXIBILITY TRADING

To use the full potential of the data in flexibility trading on LFM, the stakeholders must use advanced analytics to achieve a suitably strong position on the market. Embedding data-driven decision-making processes and practices into stakeholder operations and encouraging them to use data to inform their decisions, validate assumptions, and measure performance, will foster improvements in flexibility trading. Further, monitoring the performance of data-driven initiatives and collecting feedback from stakeholders is needed to identify areas for improvement.

Deploying integrated digital platforms that leverage IoT devices, edge computing, and cloud technologies to facilitate real-time data collection, processing, and analysis, enabling seamless market operations and optimization. Deploying edge computing technologies to process and analyse data at the edge of the network, closer to the data source. Edge computing reduces latency, bandwidth usage, and processing costs, enabling real-time data analytics and decision-making in flexible markets.

4. CONCLUSIONS

The appropriate management and optimized trading of the flexibility require market-based approach. There are different barriers and challenges, as well as conflicts that must be addressed, alongside concerns regarding data privacy, cybersecurity, and regulatory compliance. It can be resolved by carefully thought out of data ownership, access, and utilization among stakeholders. It is essential for fostering trust and cooperation within flexibility markets. As presented in this work, the measurement and control scenario behind the flexibility trading is far from trivial.

REFERENCES

1. Villar J., Bessa R.: Flexibility products and markets: Literature review, Electric Power Systems Research, 2018.
2. Ziras C., Heinrich C., Bidner H.: Why baselines are not suited for local flexibility markets, Renewable and Sustainable Energy Reviews, 2021.
3. Dognini, A., et al.: Blueprint of the Common European Energy Data Space, Interoperability Network for the Energy Transition (int:net), 2024.
4. Council of European Energy Regulators, Flexibility use at distribution level, CEER, 2018.
5. Degefa M., Sperstand I., Sæle H.: Comprehensive classifications and characterizations of power system flexibility resources, Electric Power Systems Research, 2021
6. Chondrogiannis, S., Vasiljevska, J., Marinopoulos, A., Papaioannou, I., Flego, G.: Local Electricity Flexibility Markets in Europe, JRC European Union, 2022
7. Pressmair G., Kapassa E.: Overcoming barriers for the adoption of Local Energy and Flexibility Markets: A user-centric and hybrid model, Journal of Cleaner Production, 2021