SCOPE PROJECT: AN INNOVATIVE MARKET-BASED SOLUTION TO DEAL WITH INJECTION CONGESTION

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Abstract

This paper presents the design of a local flexibility market called SCOPE (Secondary Congestion Option Platform Exchange). The aim is to deploy a local market at the distribution network level to avoid congestion and to integrate more renewable energy into the grid by making the most of flexible assets. SCOPE proposes an innovative design in which all energy and financial exchanges are conducted on a peer-to-peer basis between decentralised energy producers and flexibility providers, eliminating the need for the DSO to buy flexibility itself. The ecosystem and the various incentives for players in this market are discussed together with the challenges involved. The main challenges concern the regulatory, algorithmic (bid matching algorithm) and simulation aspects (to measure financial and network reliability impacts). Practical implementation aspects are also discussed based on the demonstrators in the ORES network. These include the choice of pilot zones, fallback solutions, the regulatory sandbox and cybersecurity. Preliminary studies and discussions with the different players of the energy sectors show that the proposed design is of considerable interest to the electrical industry with tremendous potential for accelerating the energy transition.

1 Introduction

1.1 Background

In Belgium, the penetration of decentralised renewables in the medium-voltage grid (6-15 kV) has been steadily growing for several years, mainly due to the connection of wind farms to this part of the grid. This creates new challenges for Distribution System Operators (DSOs) and necessitates active network management strategies [1] to avoid congestion during times of high renewable energy production. Active network management (ANM) refers to the modulation of generation sources, loads, and storage to reliably operate the electrical network without relying on significant infrastructure investments [2]. Although the ANM-based solution employed by most European DSOs involves straightforward curtailment of loads or renewable generation [3], some have taken the next step in the Net-Zero journey by deploying local flexibility markets to manage their systems [4]. A local flexibility market is a marketplace designed specifically to procure flexibility within a geographically defined area to manage congestion and/or voltage at a local level [5]. In these markets, the DSO traditionally acts as the main buyer, responsible for publishing calls for tender (definition of the flexibility needs and their locations), purchasing flexibility services and managing all other administrative aspects.

1.1.1 Regional regulatory context: It is important to understand the regulations currently in place in Belgium regarding congestion management and the modulation of decentralised production units to understand the origins of the SCOPE (Secondary Congestion Option Platform Exchange) project. When a producer is connected to the grid, they must agree with the DSO on an authorised ‘flexible capacity’ and a ‘permanent capacity’, the first of which can be modulated without fee. To put this into practice, ORES, one of the largest DSOs in Belgium, uses a predictive algorithm to dynamically manage the congestion risk (at the period T-5 minutes) and to send a setpoint (maximum production to be injected) to be respected by the generation units. This setpoint may modulate the production downwards, within the limits of the flexible capacity of the unit. The main features of this algorithm are explained in reference [6]. We note that the product behind this algorithm, Smart Active Network Operation (SANO), has been adopted by several DSOs and has been commercialised by Haulogy.

1.2 SCOPE project

In this context, it would be advantageous to rather adopt a commercial flexibility approach to reduce unit curtailment by identifying demand response solutions capable of absorbing such production surpluses. Among others, more renewable energy would be injected into the network and new revenue streams would be made accessible to flexibility providers (see Section 2.2.3). Figure 1 shows a basic scenario where the wind turbine receives the modulation order from the DSO while other flexible loads present on the local network could absorb the congestion at the transformer. With the SCOPE flexibility market platform, the producer could activate the bids of the flexible loads so that their consumption increases, and the congestion risk is removed without requiring any curtailment.

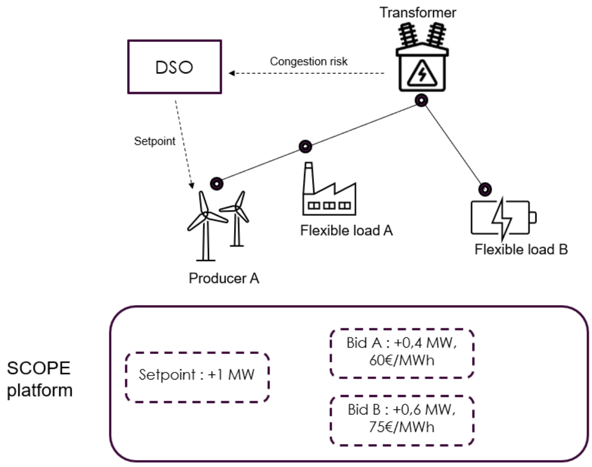

Figure 1- Illustrative diagram of a congestion resolution scenario with SCOPE platform.

The ambition of the SCOPE project is to deploy a market platform relying on an innovative market design where the DSO does not buy flexibility itself, and all energy and financial exchanges take place on a peer-to-peer basis between energy producers and flexibility providers.

We believe that this market design can offer several advantages over other existing platforms [4]. Firstly, it requires less time and resources from the DSO, who does not purchase the flexibility (the producer is responsible for this) and reduces the administrative burden. Secondly, the presence of several potential buyers avoids a monopsony situation. This avoids certain market distortions, such as the setting of a maximum price by the DSO.

In this paper, we describe the different elements of the SCOPE research project articulated both around industrial partners (Haulogy, OakTree Power, CE+T) and universities (ULiège, ULB). The ecosystem and the various incentives for players in this market are discussed together with the challenges involved. It also focuses on the practical aspects and the development of all the required tools and knowledge for this platform to be a success. The ambition is to have at the end of this project a product that could be commercialized all over Europe. We believe that this product will greatly help to maximize the available renewable energy injected into a distribution grid while driving down the producers operating costs incurred by the volumes curtailed. We also believe it will create significant new market opportunities for flexibility providers and, hence, acting also as an accelerator for the flexibilization of loads and the investment in storage devices.

2 SCOPE ecosystem

The overall aim of the project is to create a market dynamic between two key groups: producers who are limited by network capacity and occasionally receive modulation orders, and consumers who own flexible assets. These assets are capable of providing a demand response solution to congestion problems caused by renewable energy, which often occur during production peaks. These exchanges aim to mitigate the risk of congestion for the DSO, just as curtailment did in the past. This shift from so called “technical” to “commercial” flexibility unlocks the potential for a higher level of efficiency since previously unproduced MWh can be injected without increasing the congestion risk.

2.1 SCOPE basic operating mode

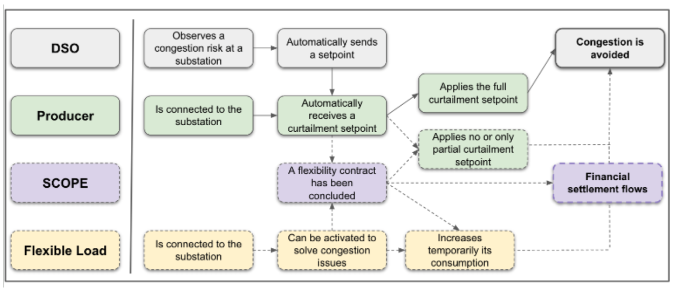

Figure 2 : A SCOPE basic operating diagram.

Figure 2 provides a conceptual representation of how the SCOPE market operates in a happy-flow situation, which refers to a situation where the behaviour of each player has complied with what was expected by the initial market design and that no penalty has been imposed for any failure to comply with the instructions of the platforms. The software platforms will automate the prediction of congestion, the sending of the setpoint and the optimal choices for each actor (bidding, bid selection, curtailment decision, etc.) through optimisation algorithms. The aim is to avoid congestion cost-effectively, i.e., by minimizing the necessary resources to integrate the most renewable energy in the network, within a very short time. The way this cost-effectiveness is measured is explained in Section 3.3.

2.2 SCOPE players

2.2.1 DSO: Although the DSO does not buy flexibility directly from the SCOPE platform, it will still trigger flexibility exchanges by sending the setpoint instructions to the producers. The DSO can also be involved by acting in the regulation of conflict situations between platform users and penalising behaviour that is contrary to the operation of the market. An example could be a flexibility provider who does not activate their load correctly to absorb congestion (it then forces production to be curtailed). This kind of event is part of what is known as ‘out of happy-flow management’. This expression refers to any situation where the behaviour of at least one player has not complied with what was expected by the original market design or if a technical reason prevents the market from running smoothly.

There are many reasons why DSOs are interested in this kind of solution. Firstly, in the short term it provides an economically preferable solution for some grid users to manage the risk of congestion. Indeed, producers and flexibility providers theoretically find a direct economic incentive in using the SCOPE market: producers can produce more, and flexible assets are remunerated for services delivered. From a DSO’s point of view, this improves customer satisfaction and attracts potential new customers, fastening the energy transition. Additionally, all users of the distribution network may be able to pay lower network tariffs if the DSO manages to reduce its CAPEX expenditure and therefore its overall costs. In the long term, it also allows more renewable generation to be integrated without any CAPEX investment in the grid.

2.2.2 Producers: Decentralised and renewable producers have an obvious interest in this platform, as it means that they do not have to curtail production when network capacity is not sufficient to avoid the risk of congestion. However, sufficient flexible assets must be available at the right localisation on the distribution network to absorb this surplus production: it is possible that demand response may not be sufficient to absorb everything (in this case, an optimal mix of curtailment and commercial flexibility will be found by the platform), or may even be totally absent, depending on the topology of the network.

2.2.3 Flexibility providers: Flexible assets are either existing industrial processes (HVACs, cooling systems, heat extractors, etc.,) or storage solutions (BESS) each of which are loads that can be increased in order to ‘absorb’ the surplus injection. It is important to provide this response locally since congestion is measured on a targeted element of the network: a substation, a line, a transformer, etc. Customers are generally industrial or commercial buildings capable of absorbing large volumes fairly quickly. Aggregated domestic assets (LV networks) are not initially considered in the project, as the regulatory, technical and commercial challenges encountered are different. However, the integration of these will be studied at a later stage.

The benefits for industrial or commercial consumers owning flexible assets are multiple. Firstly, the load increases associated with the use of SCOPE enable them to potentially purchase energy at a lower price. Indeed, producers seeking to sell these surpluses will have to offer a sufficiently attractive price to motivate demand to temporarily change consumption behaviour. To do so, other factors that can influence the price of energy also have to be taken into account. It is indeed possible that a flexibility provider may not want to temporarily increase its energy consumption because of conditions in other markets (e.g., energy prices on the supplier side could be temporarily higher). Lastly, it should be emphasised that these local flexibility platforms add value to flexibility at the distribution level. In this respect, it may trigger users that were hesitant to invest into flexibility, because of poor business cases, to invest into it. As a result, we cannot exclude that those local flexibility platforms may also bring more flexibility to other energy and balancing markets, even if we recognise that these local flexibility markets may at some time, cannibalise all the local flexibility and, hence, deprive other markets from it. In short, the SCOPE project offers at least the possibility of additional remuneration and better return on investment for flexible assets.

3 Open research questions and challenges

We list here a series of challenges and research questions related to the SCOPE project, to which we will attempt to provide answers during the project.

3.1 Regulatory aspects

Implementing a market of this type requires significant regulatory changes, as the DSO delegates part of its responsibility (in terms of network management) to its users. These changes relate to the following questions: who is responsible for congestion management? How can the network codes be adapted to ensure that the market functions properly? What type of new contract should be put in place between the DSO and customers integrating the platform? Coming back to the example of Figure 1, we could imagine the producer simply paying the bid asking load A to consume more, but we could also conceive of a real transfer of energy [7] between the two players. To meet these challenges, several points need to be highlighted. Firstly, close collaboration with the local regulator is planned throughout the project to ensure that the design chosen meets the expectations of each user as well as those of the regulator (see also Section 4.2). In addition, it is possible to keep certain steps under the control of the DSO, even if exchanges take place directly between producers and consumers: for e.g., baseline method, settlement, etc.

3.2 Network security

How can we guarantee that the exchanges undertaken on the SCOPE platform will not affect the security and reliability of the network? Will the risk of congestion effectively be mitigated? To deal with these questions, we will develop a simulation tool to anticipate the impact of these flexibility exchanges on the distribution and transmission networks. We will analyse these exchanges from a technical point of view to check that they contribute to congestion management without creating new risks. The aim is to analyse the risks associated with this market from two main angles: (1) its impact - whether partial, completely successful or unsuccessful - on the configuration and composition of the physical network, and (2) the vulnerabilities introduced by the digitised platforms and intelligent devices needed to implement this market. To this end, reliability indicators such as SAIFI, SAIDI, CAIDI, LOLE or EENS[8] will be measured.

3.3 Financial interest

It is important before setting up such a local flexibility platform to be able to quantify the gains and the financial flows of the different actors. Without it, its adaptation may be problematic. This quantification will be done using the simulation tool introduced in Section 3.2. We mainly consider three players: the DSO (by estimating how many additional renewable MWh could be injected into the network without making any CAPEX investment), the producers (by comparing the scenario where they are modulated vs. the one where they can sell the surplus energy) and the flexible consumers (by observing how they optimise the profitability of their assets or minimise their energy bill).

3.4 Aggregators

Traditional FSPs (Flexibility Service Providers) are generally aggregators, with a multitude of access points to manage and optimise in order to play on the electricity markets. The algorithmic chains they use are designed to work on these markets, and not on local markets such as SCOPE. Indeed, while each bid has the same value regardless of its location in a bidding zone in the case of the wholesale market or the balancing market, this is not the case for congestion management. One of the challenges of the project will therefore be to adapt their algorithmic chains so that they could also interact with this market. The second part of the challenge will be to make the SCOPE platform sufficiently generic to allow and help aggregation platforms and Energy Management Systems (EMSs) (see Section 3.5) to interact with it.

3.5 Local EMS Optimisation

In addition to the aggregators, the other challenge is to enable 'isolated' customers running their local optimisation of their EMS to also participate in the SCOPE market. It is therefore necessary to work on the adaptation of local EMS so that they will adapt their technology to integrate local flexibility markets. This adaptation must guarantee that the local energy management system is optimised and enables the asset owner to be economically efficient. Significant co-optimisation work will therefore be carried out during the development of these algorithms, both for the platform itself and the demand response tools.

3.6 Bid matching algorithm

Matching bids is a complex issue in this market. It cannot be done based solely on cost consideration and volumes, as it is the case for energy market platforms. Indeed, the match needs also to be able to relieve the congestion problems which are targeted. This implies developing ad hoc bid-matching algorithms. If we refer to Figure 1, we can imagine a scenario where the congestion is not expected on the transformer but on the left-hand line. In this case, the platform must be able to recognise that only bid A (connected to this same line) can provide a relevant service. The battery (bid B) would only be able to help avoid congestion at the transformer and on the other line.

To operate the platform effectively, these algorithms for matching the various bids required must feature different key characteristics. The first one is genericity: bids must be validated independently of the type of asset selected and the network component subject to congestion. The second one is the speed of execution: as setpoint orders must be met within five minutes, the bid must be selected quickly so that the response to the request has time to activate. Finally, consideration of network topology and its evolution is mandatory, as it is demonstrated in the scenario above.

4 ORES network use case: practical aspects

The demonstrators of this project will be deployed on the ORES Belgian network, in collaboration with other academic and industrial researchers. The practical aspects related to these demonstrators are discussed below.

4.1 Choice of demonstrator areas

Two different demonstrator formats are planned: on the one hand, we will test the demand response capacity of an existing industrial process, and on the other hand, the absorption capacity of a storage solution (BESS) to avoid congestion and modulation of decentralised producers. The choice of test zones is based on two main criteria. Firstly, we give priority to zones most prone to congestion in previous years. Once this initial filter has been applied, we select the zones in which an appropriate demand response can be activated. To determine this, we will consider the network topology and the number of potentially flexible customers that can potentially alleviate problems on elements prone to congestion.

4.2 Fallback solutions

When carrying out the tests in real time, it is important to provide a fallback solution in case the SCOPE platform fails to alleviate the congestion. In this case, the solution we propose is pragmatic: we go back to the 'old model' which consists of sending the curtailment instruction using the SANO tool (Section 1.2.1) to modulate the production unit.

4.3 Regulatory sandbox

Close cooperation with the regulator during the project enables us to act in a regulatory sandbox during the study and observation phases of the demonstrators. This permits greater latitude in the tests carried out and more flexible adaptation of the market design to the needs of the players.

4.4 Cybersecurity

Cybersecurity aspects are also taken into account to guarantee the security of data and assets during the project. Risks are assessed and various standard measures are recommended (data encryption, authentication and access management, secure communication protocols, incident management and activity logging) for all participants.

5 Conclusion

This paper has presented the main features of the SCOPE project, which is a project that aims at creating a secondary local flexibility market mechanism to avoid congestion on the distribution network while mitigating curtailment. While the project is still in its initial phase, preliminary studies and discussions with the different players of the energy sectors have shown that it is of high interest to the electrical industry. The general design and the key challenges of this market have been identified in this paper along with the research questions highlighting the landscape for the next steps. Regular scientific communications related to this project will be published as well as suggestions for adapting network codes so as to facilitate the widespread deployment of those secondary local flexibility platforms to help accelerate the energy transition.

6 Acknowledgements

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