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SUCCESS OF LOCAL FLEXIBILITY MARKET IMPLEMENTATION: A REVIEW OF THE CURRENT PROJECTS

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SUCCESS OF LOCAL FLEXIBILITY MARKET IMPLEMENTATION: A REVIEW OF THE CURRENT PROJECTS

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Abstract

The development of distributed energy sources will challenge the management of the electrical system. Local flexibility markets (LFMs) are a promising solution to coordinate the dispatch of the distributed energy sources. Currently, the development of such markets is in its infancy and numerous challenges need to be addressed to reach market efficiency. In this paper, we focus on four topics that are crucial for the LFM success: the governance model, coordination issues, inc-dec gaming and competition. Based on a review of current project developed, we identify key challenges related to the four topics and discuss solutions to overcome these challenges. The solutions proposed are crucial to reach market efficiency and cannot be considered independently.

Abbreviations	
DER	distributed energy resources
DSO	Distributed System Operator
FSP	Flexibility Service Provider
IE	Independent entity
LFM	Local flexibility market

Keywords:

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I. INTRODUCTION

With the development of distributed energy resources (DERs), the electrical system is experiencing a dramatic change from a top-down coordination approach to a decentralized one. Technologies such as solar PV, stationary batteries, electric vehicles and heat-pumps are increasing the consumers' peak loads and the uncertainty in load forecast (Schachter et al., 2016) while also leading to feed-in of energy from the low voltage grid to higher grid levels. Also, there is a concern on the growing level and costs of the congestion at the distribution level due to the development of the DERs (Schermeyer et al., 2018). However, DERs can provide flexibility through coordination mechanisms to improve the network management (CEER, 2020).

Such coordination can be reached through local flexibility markets (LFMs). An LFM is a marketplace to sell and buy flexibility at the distribution network level or a limited geographical area (Olivella-Rosell et al., 2018; Ramos et al., 2016). The aim of this market is to enable an optimal dispatch of the DERs but also, to avoid reinforcement or investment costs (CEER, 2020). The European commission strongly encourages the implementation of such market-based mechanisms to manage congestions (European Commission, 2019). The distributed system operator (DSO) is given new roles to carry out these markets such as data management, coordination with the TSO and ensuring a level playing field between players (Pereira et al., 2018).

The development of LFMs faces some challenges but numerous projects have been implemented to test different market architectures and to validate technical processes. In the literature, these projects have been studied or compared and the results show that there is no a unique solution but a patchwork of architectures and designs (Radecke et al., 2019; Schittekatte and Meeus, 2020; Valarezo et al., 2021) that are mostly driven by local specificities (Dronne et al., 2021). Also, the review of projects allowed for a better understanding of the products traded in these markets (Heilmann et al., 2020) and also to identify issues related to TSO/DSO coordination (Silva et al., 2021). In this paper, we focus on four crucial issues for the development of LFMs: the governance model, the inc-dec gaming, the coordination and competition issues.

The governance model has not been widely tackled in the literature and is still an unsolved issue. While the Clean Energy Package is clear on the DSO's neutral role regarding the recharging points for electric vehicles and the storage ownership, the roles and responsibilities for the LFMs are not specified (de Almeida et al., 2021). In the current projects, the roles and responsibilities are either assigned to the DSO or to an independent entity (IE), especially for the implementation of the platform and the market design. Under the legal unbundling scheme, assigning the market operator role can lead to market imperfections (Buchmann, 2020; Friedrichsen, 2015; Lowe et al., 2007) because the DSO is still integrated, in many European countries, with the vertically integrated company (CEER, 2019).

Assigning the role of market clearing to an IE requires coordination with the DSO regarding data sharing. Moreover, coordination between the TSOs and DSOs is needed to ensure that the flexibility activation does not harm the TSOs' network operation. It implies information sharing between the actors which might be complicated if the actors are reluctant to share it. Another crucial issue is the inc-dec gaming which might occur under market-based mechanism for redispatch (Hirth and Schlecht, 2020). This strategy reflects potential arbitrage between the day-ahead and the redispatch market. Countermeasures must be implemented to prevent such behavior in order to prevent higher congestion volumes and costs. Another aspect which has not been widely tackled in the literature is the competition and especially, how to guarantee a high competition level. Given that LFMs cover small areas, solutions to guarantee low entry barriers and participation are highly relevant to avoid market power positions and high costs of redispatch.
Several contributions have been made regarding these topics. Alternative organizational structures have been proposed to prevent DSO's strategic behavior (Friedrichsen, 2015; Lowe et al., 2007; MIT

Energy Initiative, 2016). However, they are not compatible with the current institutional context, i.e., the legal unbundling scheme and might lead to coordination issues (Burger et al., 2019; Pérez-Arriaga et al., 2017). In (Buchmann, 2020), a governance model is proposed where all the stockholders are involved in the FLMs by setting the market rules and delegate the responsibilities in a transparent manner. Regarding inc-dec, (Martin et al., 2022) provide a major contribution on international experience. In this paper, the results of their studies will be completed by the countermeasures implemented in the project reviewed.

To fill this gap, this paper proposes to identify non-technical issues for the LFM development: the governance model, the inc-dec gaming, the coordination and competition issues. Then, solutions are proposed to overcome these challenges that are crucial to reach market efficiency. The solutions identified are based on the review of current LFM projects. Some of the mechanisms implemented in these projects are not meant to deal specifically with the issues identified and can be considered as a basis of discussion. Finally, regulatory recommendations for the LFM implementation are derived.

This paper is organized as follows. In section 2, we identify non-technical issues with the development of LFMs. In section 3, we describe the projects reviewed. In section IV, we discuss the solutions implemented in the current project to overcome the challenges identified in section 2. In section 5, we propose policy recommendations to guarantee the efficiency of the LFMs.

II. DRIVERS OF THE LFM SUCCESS

2.1. Governance issues

The flexibility procurement in a LFM can be organized in different ways. First, the DSO can contract with a flexibility service provider (FSP) to determine an amount of flexibility to be procured at a certain point in time and location. Such bilateral contracts avoid the implementation of a platform. It can be relevant for areas with a low congestion frequency and a few FSPs. Conversely, the establishment of bilateral contracts would lead to high transaction costs. Besides, when the congestions tend to be more sporadic with differences in size and depth, the contracts would need to continuously be adjusted. In this case, a market platform is suitable to decrease the transaction costs.

In the current projects, the design of the platform is heterogenous and differs from the service provided. There are two main platform models: the market intermediaries and the marketplaces (ENTSO-E, 2021). The latter is run by an IE and provides all the services to the DSO such as the bid collection, the market clearing and the settlements. The market intermediaries provide less services, especially not the clearing. The aim of such platforms is to facilitate the trading by providing an order book or other services to the DSO. The choice for the DSO in outsourcing the tasks to an IE depends on the transaction costs. The DSO performs the tasks for which he has the expertise on and contracts with a third-party for the tasks which he does not have the know-how (Williamson, 1979). Some DSOs do not have the expertise for implementing a marketplace but do have an experience on specific roles such as the identification of the congestions or the development of technical-economic algorithms to select the optimal offers. In that case, the cost of internalizing these roles is lower than procuring them from the market.

However, if the DSO runs the market by performing all the roles, critical market imperfections might occur in some cases (Lowe et al., 2007). In Europe, most of the DSOs are still integrated with the historical vertically integrated utility. This is due to the legal unbundling that requires the creation of a separate entity for the network management, but the new entity can still be owned by the vertical

utility. Even if a compliance program has been implemented enabling the regulator to penalize the DSOs if they do not respect the European directives, strong market imperfections can occur if the DSO runs the market (Buchmann, 2020; Burger et al., 2019). First, the DSO can favor its affiliated undertakings during the market clearing even if some offers are more efficient to solve the congestion. Second, the DSO might not be willing to report strategic behavior or market power from his affiliated undertakings. Third, asymmetric information might occur if the DSO shares in advance the location and characteristics of forecasted congestion. In this case, the affiliated undertakings can anticipate the investments or the marketing processes to capture the flexibility assets in their portfolio. This would create an entry barrier for the potential competitors if the remaining flexibility assets were low. Also, the DSO could provide strategic information on the competitors to his affiliated undertakings such as their technical abilities and their bids. Moreover, the DSO can set the rules to favor his affiliated undertakings. For instance, complex rules for the certification process and the contracts with the flexible assets might favor the historical incumbents. This is especially true with high asymmetric information between the DSO and the regulator. If the regulator has little information on the effect of the rules on market participation, the DSO might define them to increase entry barriers for new participants. Fourth, a risk of strategic investment withholding can occur (Balmert and Brunekreeft, 2010). To solve recurrent congestion, the DSO defines the best solution between network reinforcement/investment and the market. If the costs of the network reinforcement are cheaper but the DSO chooses to solve the congestion through the market to guarantee a revenue for its affiliated undertakings, the costs borne by the network user will be higher.

Under a legal unbundling scheme, a strong regulation and incentives could prevent these market imperfections. Indeed, if the incentive mechanism is designed as such the DSO captures significant gains from these markets, it would be incentivized to procure the most efficient flexibility with high level of competition. However, setting adequate incentives might be difficult in practice and it is complex to remove all the asymmetric information between the regulator and the DSO. To prevent from discriminations, new organizational structures have been proposed such as ownership unbundling or an independent distribution system operator (Friedrichsen, 2015; MIT Energy Initiative, 2016). These models are effective to increase the competition by preventing DSO's misbehavior. However, these organizational structures may harm coordination because of the transaction costs (Burger et al., 2019; Newbery, 1999). It is not clear yet if the benefits of alternative organizational structures would outweigh the costs. In this paper, the different options to assign the roles and responsibilities in the current projects will be analyzed regarding the market imperfections described above under the legal unbundling scheme.

However, the choice of the platform does not depend only on the DSO's abilities to internalize some activities. Other actors will be interested in the DER flexibility such as the TSO for balancing or voltage control and the balance responsible parties to correct their imbalances. Different LFM architectures have been proposed to consider an integrated market with multiple buyers (Gerard et al., 2018).

2.2. Coordination issue

A crucial success of the LFM implementation is the transparency of the rules and especially on the market clearing process. If an IE performs the market clearing, the DSOs must cooperate by sharing information on the network such as the grid status and topology. This process would avoid some of the market imperfection described in the previous sub-section. Also, implementing an automatic process avoids manual decisions taken by the DSO. This would probably harm the market parties' confidence and so, the participation (Stevens et al., 2021). However, the DSOs have the information on the network constraints and should know which bids efficiently solve the congestion. If the market is cleared by an IE, the DSOs must be reluctant to share private information on their network. Some adequate tools must be developed to perform the market clearing by minimizing the

information sharing between the parties.

Another crucial challenge for the LFM success is the DSO/TSO coordination. The activation of a flexibility at the distribution level can violate the constraint at the transmission level and conversely. Moreover, a bid can be used for different services at both distribution and transmission level. Hence, the DSOs and TSOs must cooperate to minimize the system costs through flexibility activation at both the distribution and transmission level. Such coordination requires data sharing between the grid operators. Currently, the TSOs and DSOs already share some data but the type of data and the frequency differ across countries (Prettico et al., 2021). These data include generation and load forecasts, schedule of power units, real-time measurements, ex-post measurements, TSO's network conditions. In some jurisdictions, these data transfers are mandatory and are transferred at different timescales. In the context of the LFM, the main questions regarding the data sharing between the TSOs and DSOs are:

- What types of data (forecasts, scheduled data, real-time/ex-post measurements)?
- Which exchange rates (daily, hourly, real-time)?
- Which point of the distribution?

The answers are not straightforward and depend on local contexts and especially, the coordination mechanism between the DSOs and the TSOs.

2.3. Inc-dec gaming

Market-based redispatch mechanisms are advocated by the European Commission because it would lead, in theory, to an increase in efficiency compared to other solutions such as cost-based mechanisms or renewable curtailment. However, under a sequential market with different granularity (zonal and nodal), strategic behavior might occur. When the market parties are able to anticipate a congestion at a node or a series of nodes, they are incentivized to deviate their bid in the day-ahead (spot) market from their true costs in order to exacerbate the congestions with the aim of increasing their profits (Hirth and Schlecht, 2020). For instance, if a market party anticipates a need for ramping down on the redispatch market, it will be incentivized to decrease the bid on the spot market in order to increase the dispatch volume at the export constraint node. This will aggravate the ramping down needs and increase the market party's revenue from the redispatch market. Conversely, the market parties at the import constrained node are incentivized to increase the bid to increase the need for ramping up on the redispatch market. This will exacerbate even more the congestion and the costs to manage it.

Such behavior called "inc-dec gaming" is a significant challenge for the LFMs. If inc-dec gaming cannot be monitored or prevented, the development of LFMs is doomed to failure because the congestion levels and costs might increase compared to the status quo. Such behavior has already been experienced at the transmission level and has even resulted in a change in market design towards nodal pricing as in California (Harvey and Hogan, 2001; Wolak and Bushnell, 1999). However, congestion anticipation might be more complex at the distribution level for several reasons (Bjorndalen, 2020). First, load forecasting is more difficult to forecast at the disaggregated level, especially with the development of more and more price responsive technologies. Second, it is not obvious how the dispatch in the wholesale market would affect the market for local congestion. Third, the expected profit might be significantly lower at the distribution level since the depth of congestion would be lower. Fourth, time-coupling constraints of storage systems reduces the possibility of inc-dec gaming (Schmitt et al., 2021).

Moreover, the experience of inc-dec gaming in Europe is low and can be attributed to a lack of competition (Martin et al., 2022). Hence, measures to ensure high competition level is crucial and will be discussed in Section 2.4. As the LFM development is still recent, inc-dec gaming is not

expected but some experiences from current projects to prevent inc-dec gaming will be identified.

2.4. Entry barriers and participation

A crucial driver of the LFM success is the entry barriers which affect the participation. The LFM design needs to unlock the flexibility potential from DERs to benefit from low-cost flexibility offers. However, ensuring a high level of competition is not straightforward in the case of LFMs. For the definition of the product, there is a trade-off between standardized and specific products. The former is a predefined set of fixed values across the product parameters while the latter allows the DSO to change the parameter values for each transaction (ENTSO-E, 2021). To encourage more actors to participate, standardized products are suitable but the congestion needs can be very specific and the products for congestion can include a lot of attributes (Heilmann et al., 2020; Zhang et al., 2014). However, a minimum harmonization is needed to increase the participation because the flexibility is monetized in several different markets with different rules and processes. If the products are different between the LFMs and if numerous marketplaces are expected, the participation cost of participating in multiple markets will be tremendous. This is also advocated by the directive of the internal market (Art. 31.2).

In a market, numerous offers from diverse actors are usually deemed necessary to ensure a high level of competition but it is not always the case. As long as the market is contestable, the market parties will tend to bid their true costs even if the number of actors is low. This is only true if there are no entry barriers. This is a crucial aspect of the LFM success which has not yet been tackled. In some areas, historical incumbents can have a better knowledge of the potential flexibility assets. Moreover, the flexibility level from the households can be significant but the high number of small assets can lead to a heavy marketing process. The creation of a flexibility portfolio from small assets could be too costly for some actors and so, be reluctant to enter the market. The development of different tools should be implemented in order to have clear and transparent information on the market potential for all market parties. This would ensure a high level of competition.

The penalty scheme has important implications for the competition. If the penalty is based on the costs induced by a service failure, it would be unpredictable for FSPs. This would probably decrease the FSPs participation. Moreover, it would be difficult to determine the responsibility and the corresponding share if more than one FSPs deviates from their bids (Lehec, 2019). So, there is a trade-off between a level of penalty that would not discourage potential actors and a level that reflects the costs of a failure.

III. PROJECT REVIEWED

Congestion management at the distribution level is currently an issue in some jurisdictions. Several marketplaces have been developed through regulatory sandboxes because the current regulation does not provide incentive for LFM implementation. There are also projects developed under the EU's research and innovation funding programme called Horizon 2020. These projects cover various topics and aim to experiment new technologies and new business models for the flexibility procurement. The project reviewed in this paper focuses mostly on congestion management and provides interesting feedback regarding the issues identified in section 2.1.

Regarding commercial implementations that are still active, the *Cornwall Local Energy Market* project has developed a marketplace that allows the DSO (Western Power Distribution) and the system operator (National Grid Electricity System Operator) to procure distributed flexibility within the geographic area of Cornwall (Atkinson, 2020). The aim is to alleviate power flow constraints during peak loads and to provide frequency regulation. In phase 2 of the trial, both actors compete to procure flexibility services through a common market. A commercial clearing algorithm was

developed to select the best offers between the DSO, the system operator and the FSPs. In France, the main[5] DSO (Enedis) has launched a call for tenders for congestion management in different areas. The main objectives are to improve the integration of the renewables in the network by including the flexibility potential in the planning and to postpone network investments (Enedis, 2019a). *IREMEL* is a Spanish initiative promoted by the Iberian market operator. Four different market models are considered using global and local approaches: Global market without and with potential distribution grid constraints, Local market for network congestion management and Local market with persistent grid constraints. In the UK, *Piclo Flex* is a marketplace launched in 2018 and run by an independent software company. Four DSOs procure flexibility for congestion management (in their respective areas). One of the main objectives is to provide a transparent market design, to reduce entry barriers and improve coordination between the network operators.

Regarding research or pilot projects, different LFM aspects are covered. *Altdorfer Flexmarkt* is a project developed within C/sells with the objectives to unlock existing small-scale flexibilities by identifying them and lowering entry barriers (Zeiselmair and Köppl, 2021). The *Flech-iPower* project mainly focused on the product definition with detailed parameters and on the interactions within the market. *Enera* is a regional market intermediary that centralizes the request and offers through an order book. The aim is to solve congestion at the distribution level and to reduce renewable curtailment. The platform is managed by EpexSpot and runs in parallel to the intraday market (Enera, 2020). The *InterFlex* project focuses on many LFM aspects but the Dutch and French demos aim to develop new business models and scalable solutions. The *Nodes* project aim is to implement an independent marketplace to exploit all the flexibility sources available. The platform is integrated with different markets allowing FSPs to sell flexibility for DSOs, TSO in the reserve market and BRPs at the DAM/IM. The *WindNODE* project aims at integrating current flexibility assets not covered by regulatory dispatch by lowering entry barriers.

Some projects are dedicated to the TSO/DSO coordination. For instance, the *SmartNet* project aims to provide tools in order to improve the coordination between the DSOs and TSOs but also to improve the exchange of information between them. One of the main contributions is to categorize and evaluate different TSO/DSO coordination mechanisms. Other projects are still under the development phase and the results are not yet available but some insights are already provided. This is the case of the *Coordinate* project that will test different collaboration schemes between TSOs, DSOs and consumers. Standardized products will be defined to enable a seamless pan-European electricity market. The *Interrface* project aims at developing a common architecture to connect existing data hubs which improve the data sharing between the network operators.

The success of LFM relies on the digitalization and the development of business models to attract new market parties. To this end, the InteGrid project objective is to develop tools for facilitating the participation of the end-users in flexibility procurement through data management and the implementation of new business models. A grid and market hub are developed with the objective to share transparent information between stockholders for different use cases such as congestion management.

[5] Enedis covers 95% of the national consumption at the distribution level.

Table 1: Description of the LFM projects

Projects	Date of completion	Main objectives	Reference
Altdorfer Flexmarkt	2020	Unlock small-scale flexibility	(Harper, 2019; Zeiselmair and Köppl, 2021)
Coordinet	2023	TSO/DSO coordination	(Stevens et al., 2021)
Cornwall LEM	Active platform	Decrease peak load (DSO) and to provide frequency regulation (system operator)	(Atkinson, 2020)
Enedis' marketplace	Active platform	Unlock small-scale flexibility	(Enedis, 2019a, 2019b)
Enera	2020	Decrease renewable curtailment	(Enera, 2020)
Flech-iPower	2016	Product definition	(Heinrich et al., 2020; Zhang et al., 2014)
InteGrid	2020	Platform for data-service driven	(Cossent et al., 2020)
InterFlex (French and Dutch demos)	2019	Unlock small-scale flexibility	(Lehec, 2019; Willems, 2018)
InterrFace	2021	Develop an interoperable pan-European grid services architecture	(INTERRFACE, 2020)
IREMEL	Active platform	Unlock small-scale flexibility	(OMIE, 2019)
Nodes (Mitnetz Strom)	Active platform	Decrease renewable curtailment	(Engelbrecht et al., 2019)
Piclo Flex	Active Platform	Standardize and facilitate flexibility procurement process for DSOs	(UKPN, 2021)
SmartNet	2019	TSO/DSO coordination	(Marroquin et al., 2019)
WindNode	2020	Unlock small-scale flexibility	(WindNode, 2021)

IV. SOLUTION PROPOSED FOR THE LFM SUCCESS

4.1. Governance of the LFMs

Defining the best governance model is a complex task. Usually, the debate (under the legal unbundling scheme) is bounded by either allocating the role of the market operator to the DSO or an IE. However, in the project reviewed, the definition of the roles between the two actors can be very different because some roles can be split into sub-roles. So, there are a multitude of possibilities and the choice in role allocation must mitigate the asymmetric information and the discrimination.

First of all, it is necessary to hide some information to the DSO, especially on competitors such as the name of the companies. An IE or a data operator must collect the information during the certification and bid collection phases in order to send only the necessary information for running the market. In the InterFlex project (French Demo), the DSO performs all the roles except that the platform (e-flex) can make the flexibility sources anonymous.

Another step is to split the roles between the DSO and the IE. Usually, the certification role is performed by the DSOs, at least the technical one, because they have the best information on the asset location. In the Cornwall LEM project, the FSPs have to register their information regarding their flexibility assets and an IE checks only the location using a postcode-to-substation mapping provided by the DSO. However, there is no certification process to ensure that the FSPs are able to provide the flexibility. For the market clearing, it is also possible to split the role between the DSO and the IE. In the IREMEL project, the DSO validates the bids based on a technical analysis and sends the results to the IE which then clears the market. In the ReFlex project, an IE sends the offer to the DSO but without the price. The DSO has only the information on the technical parameters and selects the offers that fit with his needs. Then, the DSO sends his choice to the IE that clears the market based on a techno-economic optimization. Even if the DSO favors his affiliate undertakings during the technical selection, it is not guaranteed that they will be selected during the techno-economic process. Moreover, it is easier to monitor the DSO's behavior. A step further would be to allocate the roles of the bid selection and the clearing to an IE. In this case, there is an issue of information sharing from the DSO and the IE. The resulting coordination issue will be discussed in section 4.3. Another option would be to define a methodology validated by the regulator or the market operator. In the Flech-iPower project, the DSO identifies the congestion but the methodology for the load forecast is defined by the market operator.

Another issue identified in section 2.1 is relative to the asymmetric information between the DSO and the regulator. In jurisdictions with weak regulators, the DSOs might define the market rules to favor the historical incumbents and so, their affiliated undertakings. In this case, an IE that acts as the market operator should define the rules to access the market. Several options have been implemented to avoid high transaction costs and burdensome procedures to enter the market. For instance, if a technical test is required for certifying the assets, an individual test for each flexible asset would lead to burdensome process for FSPs with numerous small units in their portfolio (INTERRFACE, 2019). So, aggregating the load as a whole during the certification process is desirable to lower entry barriers for some actors. The certification rules must also be set by considering other products to avoid having to duplicate the procedure. Moreover, this procedure could be burdensome if the certification time is short which would oblige FSPs to repeat the process multiple times. In Piclo Flex market, the length of time for the certification is defined in advance to avoid having to repeat the procedure for each market phase. Hence, the regulators have to evaluate the impact of the market design on the participation for different type of actor and with different flexibility portfolio. This analysis should be carried out with the existing rules and network codes regarding the certification of the assets because the existing rules should not lead to entry barriers for some actors.

Another asymmetric information is regarding the identification of the congestion. The DSOs could share in advance the location to their affiliated undertakings. However, there are two options to prevent asymmetric information. First, through the regulation. Article 32.4 D-IMED requires the DSO to publish at least every two years a transparent network plan. This plan "shall provide transparency on the medium and long-term flexibility services needed and shall set out the planned investments for the next five-to-ten years […]. The network plan shall also include the use of demand response, energy efficiency, energy storage facilities or other resources that the distribution system operator is to use as an alternative to system expansion". This regulation prevents strategic information sharing as all competitors have access to the forecasted flexibility service needs.

Table 2: Role allocation for the certification, bid collection and the market clearing for the project reviewed

Projects	Certification	Bid collection	Market clearing
Altdorfer Flexmarkt	DSO	IE	IE
Cornwall LEM	IE (Centrica)	IE (Centrica)	IE (Centrica)
Enedis' marketplace	Enedis	Enedis	Enedis
Enera	IE (Epex Spot)	IE (Epex Spot)	DSO/TSO
Flech-iPower	IE	IE	IE
InterFlex	DSO	DSO	DSO
IREMEL	IE (OMIE)	IE (OMIE)	IE/DSO
Nodes (Mitnetz)	IE/DSO	IE	DSO
Piclo Flex	DSO	IE (Piclo)	IE (Piclo)
ReFlex	DSO	IE	IE/DSO
WindNode	DSO	DSO	DSO/TSO

4.2. Tools to improve the coordination

A significant step towards a more efficient market is through data sharing between the DSOs and the IE to improve the transparency in market clearing. Some projects have developed some tools allowing the IE to clear the market with limiting information on the distribution grid.

In the Altdorfer Flexmarkt, the DSOs need to create a topological assignment matrix to benefit from the services provided by the platform. This matrix allows the IE to assess if a flexibility offer can solve the congestion at the node through influence factors. These influence factors are uploaded to the flexibility platform by the DSO. It allows the market operator to identify if a flexibility offer solves the congestion and so, to accept the bids or not. The DSO does not provide any information regarding the network model nor the load flows (only congestion). In the Cornwall LEM, the DSO provides a hierarchical mapping of the network assets to the market operator. It allows the market operator to check if a bid solves the congestion at the substation.

Regarding TSO/DSO coordination, the current projects assume transparency in data sharing between the DSOs and the TSOs and it is a prerequisite to the LFM success. Nevertheless, the amount of data sharing depends on the coordination model implemented and on the specific configuration of the market (Hadush and Meeus, 2018). The coordination model depends on which actor has the

priority on the flexibility offered and the centralization level of the clearing. A common TSO/DSO market with a central clearing leads, in theory, to an optimal solution compared with other mechanisms (Stevens et al., 2021). Both operators compete in the same market for the access of the flexibility connected at both the distribution and transmission levels. However, this model has several drawbacks mainly due to the complexity of the clearing process that requires a lot of data and also due to data privacy issues (Silva et al., 2021). Different solutions are being tested to avoid such complexity such as technical aggregation strategies (Givisiez et al., 2020).

The simulations performed in the Smartnet project show that in some cases the local DSO model in which the DSO has the priority on the distributed flexibility can outperform the common DSO/TSO model (Rossi et al., 2020). This is the case for areas with high congestion frequency and more flexibility assets connected at the distributed level. This model limits the need for data sharing because the DSO can send unused bids that will not violate the distribution network. Also, both network operators can agree on the desired flexibility at the TSO/DSO connection points. For congestion management, the first simulations within the Coordinet project show that defining a subscription capacity for preventing the interface power flow between the DSO and TSO requires limited data sharing. The performance of the TSO/DSO coordination models by considering the data privacy issues remain an open question that the project under development should focus on.

A critical issue that has not been addressed for the TSO/DSO coordination is the incentives. How to design an incentive mechanism that encourages both TSO and DSO to minimize the overall system costs? For instance, the activation of a flexibility at the distribution level can minimize the DSO cost but could be not efficient to minimize the overall cost. Also, it is not clear yet how to allocate the benefit and the costs of flexibility activated generate benefits for both network operators. Moreover, the DSOs and TSOs will be forced to block some bids activated by other network operators. In this situation, there is a need to define adequate compensation.

4.3. Solutions to prevent inc-dec

Different options have been discussed to prevent inc-dec gaming but the issue is not usually tackled in the current projects. In fact, such behavior is not expected during the validation test of the projects. However, some interesting measures implemented in a few projects need to be highlighted and can be categorized as ex ante and ex post measures.

Regarding ex ante measures, numerous projects involve long-term contracts which avoid gaming possibility. Even if all market parties can bid when a congestion has been identified, if the DSOs deem that the bids are too costly, they have the possibility to activate bids from long-term contracts at a price defined ex ante[6]. Another option is to set a price cap which can be set according to the DSO's willingness to pay, i.e., the cost of failure or of alternative measures (Bjorndalen, 2020). Without alternative measures, the cost of failure might be high and so, expected revenue from inc-dec gaming would be significant. In this case, setting the price cap is not trivial. An effective measure is to develop alternatives for congestion management. In the InterFlex project (Dutch demo), two flexibility mechanisms were combined: a LFM and a variable capacity connection. The latter corresponds to a variable capacity profile that allows the DSO to lower the capacity connection during peak load periods (Fonteijn et al., 2018). This mechanism was implemented in case of a lack of flexibility offers. However, this option can be seen as an alternative to the DSOs if bid prices are deemed too high. Another option discussed is the randomization of bid selection. In the ENKO project, they discussed the possibility of applying a random algorithm to select the bids or to activate a random share of the flexibility volume offered. This mechanism would lead to lower expected revenue because the probability of not being cleared in the market is significant (Brunekreeft et al., 2020). Nevertheless, this mechanism is inefficient if the bids selected are more costly and would be

[6] It is essential to define an activation price in the long-term contract. Otherwise, the bidders could overbid.

inefficient if market parties have market power.

Regarding ex post measures, a few projects test different monitoring processes to detect inc-dec gaming. In Enera, a statistical method was developed (but not implemented) to assess if the FSPs report their true baseline[7]. To do so, the model compares the baseline reported with the other baselines for the same or similar hours. In order to be effective, the model needs a significant volume of data because numerous factors can explain different levels of baselines for the same hours (different spot prices, industrial process etc.). If a systematic deviation of the reported schedules is identified, high penalties should be applied. However, this method does not enable to identify inc-dec gaming for new market players. Finally, penalties for reported strategic behavior is also an ex-post measure because the risk of financial cost can significantly decrease the expected revenue from inc-dec gaming. Countermeasures associated with dissuasive penalties can prevent such behavior (ENKO, 2021).

4.4. Solutions to lower barrier entries

Several aspects have been mentioned regarding the entry barriers such as lack of transparency due to the governance model. A crucial aspect for immature markets is to improve the participation in order to mitigate market power. In Piclo Flex, the minimum capacity required to participate in the market is 10 kW. Also, planned flexibility assets are allowed to participants and not just the assets already connected in the network. In order to incentivize different technologies with different technical capabilities, the market allows for different degrees of commitment and some contracts cover a period of 7 years which decrease the investment risks (UKPN, 2021).

An additional prerequisite of market efficiency is the information access necessary to enter the market that are available to all market parties. The tools developed in the Integrid project are relevant in this regard. In this project, a data management platform was developed which acts as a market facilitator. This central platform hub aims to facilitate market access by providing data driven services to all stakeholders (including the network operators). In this platform, the DSO provides anonymized and pre-processed metering data and information relative to the network tariff (time-of-use, dynamic tariff) or network hosting capacity. Companies can access and use these data in in order to provide data-driven services to potential market parties such as:

- Load forecast provision for the network operators, the retailers or the aggregators
- Portfolio management for aggregators based on market data, DER and load profiles
- Customer engagement strategies for retailers
- DER sizing optimization for the end-consumers/prosumers
- Electricity usage intelligence for end users that provide best information on how and when to offer flexibility.

These data driven services are crucial in order to reduce the transactions costs especially for determining the share of customers price responsive and the flexibility potential. Moreover, this platform reduces transaction costs through a unique contact point for the stakeholders and avoids adopting multiple custom protocols between several parties. Some of the services are not directly related to congestion management but some of them are indirectly related such as the DER sizing. Also, this platform aims to promote innovation in data services which could be used in LFMs. These services can be developed by companies from various activities such as software development companies, consulting companies, start-ups and data analysts. Nevertheless, on top of data privacy issues, several barriers for the development of such platforms have been identified. Regarding the

[7] For further details, see https://projekt-enera.de/blog/market-monitoring-zur-identifikation-von-strategischem-verhalten-in-flexibilitaetsmaerkten-inc-dec-gaming/

regulation, a clear data management framework is needed because alternative data sources provided outside the data platform may harm the effectiveness of this platform. Also, the deployment of smart meters is an important prerequisite for the development of such platforms.

Regarding the penalty scheme, different arguments have been advocated for the impact on the potential market parties. In the French demo of the InterFlex project, the DSO decided to set the penalty level according to the service delivered and not based on extra costs induced by a service failure. As mentioned in section 2.1, the DSO deemed that defining the penalty based on the cost of the service failure would be too unpredictable and complex to allocate the exact responsibility to the FSPs. In the Dutch demo, a high penalty level was set because, according to the DSO, the FSPs propose offers for which they are sure that the volume of flexibility will be provided. If the DSO wants further offers, it can decrease the penalty level which allows the FSPs to send offers with more uncertainties. Another option chosen in Enedis' marketplace is to set a penalty level similar to the ancillary services on the variable remuneration. For the fixed remuneration, a gradual penalty is considered and the penalty level increases based on the occurrence of the default.

V. CONCLUSIONS AND POLICY IMPLICATIONS

The development of the local flexibility market faces different challenges. The review of the current projects has shown different solutions to overcome these challenges that lead to several policy implications.

- Governance model

The current projects do not focus on the impact of the governance model on the market imperfections. This issue is crucial for the success of the LFMs and must be assessed. Even if some DSOs might have the know-how to develop a marketplace, they must not perform all the roles, especially in jurisdictions with a weak regulator. A necessary condition for the implementation of such markets is the implementation of an external platform by an independent party to hide strategic information on market competitors to the DSO. Moreover, specific rules should be defined by an independent party or at least, in compliance with the regulator. This includes the certification criteria, the product definition, the baseline definition. The regulator must assess if these rules do not impose entry barriers to new market parties. These requirements must be harmonized at the European level and should be included in the Clean Energy Package. For the moment, they are not specified in the Clean Energy Package and a recommendation could be to add such a harmonization layer in subsequent regulation such as the Network code demand side flexibility currently under discussion. However, this is challenging in areas with small market maturity. Hence, a tight cooperation might be necessary between the DSO, the market operator and the regulator to find the most efficient rules.

Also, the debate on the governance model should not be reduced on the role of the market operator. The review of the projects has shown that there are different tasks within the LFMs and that they can be allocated to the most relevant party for example the DSO or an independent entity. All these options must be assessed when evaluating the potential market imperfections. Furthermore, the assessment must consider institutional arrangements. For instance, the DSO must comply with the Clean Energy Package regarding the publication of the flexibility needs for congestion. Also, some regulators already have access to numerous information, especially for determining the network tariffs. These data can also be analyzed to perform cost-benefit analysis. In the UK, the methodology for the cost-benefit analysis to price the flexibility value is provided by the regulator. To increase in transparency, the method for congestion management and the definition of the baseline could be set incompliance with the regulator. However, it implies significant knowledge regarding the distribution network from the regulator.

- Inc-dec gaming

The inc-dec gaming at the distribution level is currently unknown but the success of the LFM depends mostly on preventing such behavior. It is not clear yet how congestion at the distribution level can be forecasted by market parties. It would probably be easier to forecast network constraints with the development of the local energy markets. The design of these markets should probably be defined in coherence with that of the local flexibility markets probably to prevent inc-dec strategies.

Under uncertainties, different ex ante and ex post measures can be implemented. These countermeasures can be implemented together in order to significantly decrease the expected return from inc-dec gaming. Moreover, market monitoring under the REMIT framework could be applied for local flexibility market.

Regarding the different mechanisms available to the DSOs for activating flexibility outside the LFMs are an effective solution. However, the cost of implementing other flexibility mechanisms should be assessed in regards to the risk of inc-dec gaming occurrence.

- TSO/DSO coordination

In some jurisdictions, the DSOs and TSOs share a lot of information for the operational management of their networks. TSO/DSO coordination is key for the efficiency of local flexibility markets and contributes to a more efficient allocation of limited flexible resources. The regulators should gather some feedback on this coordination and assess whether or not more information is needed for the LFM success. As data sharing is mandatory in some jurisdictions, this obligation could be harmonized in Europe in order to improve the DSO/ TSO coordination. Without proper regulation, some DSOs might be reluctant to share network related information that can be used to efficiently allocate flexibility and coordinate actions between the TSOs and DSOs.

More importantly, an adequate incentive mechanism must be implemented to encourage DSOs and TSOs to minimize the overall network costs. Incentive-based mechanisms are being developed but for congestion management, the regulation must not only incentivize a network operator to minimize the network management costs but also to cooperate with the other network operators to minimize the overall system costs. At the moment, the project has focused on ICT and interoperability issues but adequate incentive mechanisms must be tested.

Considering these recommendations is an important step towards the efficiency of the LFMs. A poorly adapted allocation of roles could undermine the whole design by discouraging actors from participating and by limiting the exploitation of flexible sources to efficiently manage the network.

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