European Commission

# Specification and design criteria for Local Flexibility Markets

Final report

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VITO, Belgium
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Directorate-General for Energy
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# List of Abbreviations

| | |
|---|---|
| aFRR | Automatic Frequency Reserves |
| AP | Active Power |
| API | Application Programming Interface |
| AS | Ancillary Services |
| BaU | Business as Usual |
| BESS | Battery Energy Storage System |
| BRP | Balance Responsible Party |
| BSP | Balancing Service Provider |
| CAP | Climate Action Plan |
| CAPEX | Capital Expenditures |
| CBA | Cost-benefit analysis |
| CID | Clean Industrial Deal |
| CGA | Closed Gate Auction |
| CU | Controllable Unit |
| CM | Congestion Management |
| DA | Day-Ahead |
| DC | Direct Current |
| DER | Distributed Energy Resource |
| DR | Demand Response |
| DSO | Distribution System Operator |
| EC | European Commission |
| EMD | Electricity Market Directive |
| EHV | Extra High Voltage |
| EMS | Energy Management System |
| ESS | Electrical Storage System |
| EU | European Union |
| FCA | Flexibility Connection Agreement |
| FCR | Frequency Containment Reserve |
| FGDR | Framework Guideline on Demand Response |
| FSP | Flexibility Service Provider |
| GCT | Gate Closure Time |
| GOT | Gate Opening Time |
| HEMS | Home Energy Management System |
| HV | High Voltage |
| ICT | Information and Communication Technology |
| ID | Intraday |
| ID-card | Identification card |
| IMO | Independent Market Operator |
| Inc-Dec | Increase-Decrease |
| IT | Information Technology |
| LFM | Local Flexibility Market |
| LMO | Local Market Operator |
| LT | Long-term |

| | |
|---|---|
| LV | Low Voltage |
| MARI | Manually Activated Reserves Initiative |
| MBMA | Meter Before Meter After |
| MO | Market Operator |
| MS | Member State |
| MTU | Market Time Unit |
| MV | Medium Voltage |
| mFRR | manual Frequency Restoration Reserve |
| NC | Network code |
| NDP | Network Development Plan |
| NRA | National Regulatory Authority |
| NC DR | Network Code on Demand Response |
| OPF | Optimal Power Flow |
| P2P | Peer to peer |
| PT | Publication Time |
| PTDF | Power Transfer Distribution Factor |
| p.u. | Per unit |
| PV | Photovoltaic |
| REMIT | Regulation on Wholesale Energy Market Integrity and Transparency |
| RES | Renewable Energy Sources |
| RP | Reactive power |
| SO | System Operator |
| SOGL | System Operation Guideline |
| SP | Service Provider |
| ST | Short-term |
| TC | Terms & Conditions |
| TOTEX | Total Expenditures |
| TSO | Transmission System Operator |
| USEF | Universal Smart Energy Framework |
| VC | Voltage Control |
| WTP | Willingness to pay |

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# Executive summary

## Context

The European Union's ambition to achieve a climate-neutral economy by 2050 brings significant pressure on electricity grids through increasing electricity consumption and more fluctuating and de-centralized generation. While grid investments are essential, they must be complemented by increased use of flexibility to manage fluctuations, lower costs, and secure affordable energy for all types of consumers and society. While flexibility has traditionally been managed at transmission level through ancillary services and controllable generation, the increasing connection of DERs and flexible loads at distribution level creates new opportunities and needs for distribution-level flexibility. European legislation places consumers and demand-side flexibility at the centre of the transition, culminating in the current ongoing development of a Network Code on Demand Response (NC DR).

The NC DR will ensure that demand response resources can fully participate in all wholesale electricity markets and sets out clear rules so that local services (such as congestion management and voltage control) are procured transparently and efficiently by system operators (SOs). Once adopted, it becomes legally binding. Its implementation presents challenges due to the wide diversity in grid characteristics, maturity of flexibility markets, digitalisation levels, and local energy needs across Europe. Local Flexibility Markets (LFMs) are central to unlocking the needed flexibility and therefore a key element of the NC DR. LFMs are developing at different speeds across Europe: while some already facilitate flexibility procurement successfully, others face challenges in design, implementation, or operation. There is a clear need for guidance to help Member States to establish LFMs that are effective, adapted to local contexts, and well-integrated into the wider electricity system.

## Objective

The objective of this study is to provide a unifying framework to help Member States design LFMs in a way that maximises benefits for the electricity system while placing consumers at their centre. The study **proposes a design and implementation framework to enable efficient market-based procurement of flexibility at a local level while facilitating the integration of LFM with other wholesale markets**. The study defines LFMs as markets where local services are traded, to address grid-related needs. The buyers of these services are Distribution System Operators (DSOs) and Transmission System Operators (TSOs). Local services refer to any service with a distinctly local character. In the current practice, LFMs are mostly applied in the context of congestion management and voltage control. Both markets where these local services are procured in dedicated local markets as well as through bids in other wholesale markets (day-ahead, intraday, balancing) are considered LFMs.

More specifically, the study:

- Analyses the design and implementation features of current LFM initiatives, as well as existing academic and policy research in this domain.
- Assesses various alternative market designs and associated roles and responsibilities and identifies best practices based on adequate criteria.
- Formulates key LFM success features and recommendations to assist Member States in their implementation efforts.

Particular attention is paid to the level of harmonisation of products and markets for local services. While harmonisation can reduce market entry barriers, improve liquidity, and enhance value stacking, excessive harmonisation could lead to designs that are not fit for purpose in specific local contexts.

## Methodology

The study builds on learnings from a wide range of LFM initiatives, demonstration projects, policy studies, and academic research to deliver practical recommendations for Member States developing their national terms and conditions under the future NC DR.

The work was structured into five main tasks:

- Task 1: Identification and analysis of LFMs - Relevant initiatives were identified and thoroughly mapped using a classification structure covering four categories: general information, product design, market design, and governance.
- Task 2: Definition of assessment framework - Key objectives, assessment criteria, and indicators were developed to evaluate LFMs systematically, aligned with EU policy objectives and sound market design principles.
- Task 3: Assessment and extraction of key features - Initiatives were assessed against the criteria, with key success features identified, considering factors such as liquidity, maturity, and local conditions.
- Task 4: Formulation of recommendations - Recommendations for LFM design and implementation were developed, informed by the regulatory context and assessment results.
- Task 5: Stakeholder consultation - A transversal task that gathered input, challenged interim results, and ensured validation through surveys, interviews and workshops with relevant stakeholders.

## Insights of the LFM initiatives

This study identified and analysed 37 LFM initiatives (see Figure 0-1) across Europe using a structured classification framework. Below, the main insights from the analysis of the LFM initiatives are presented for these four categories.

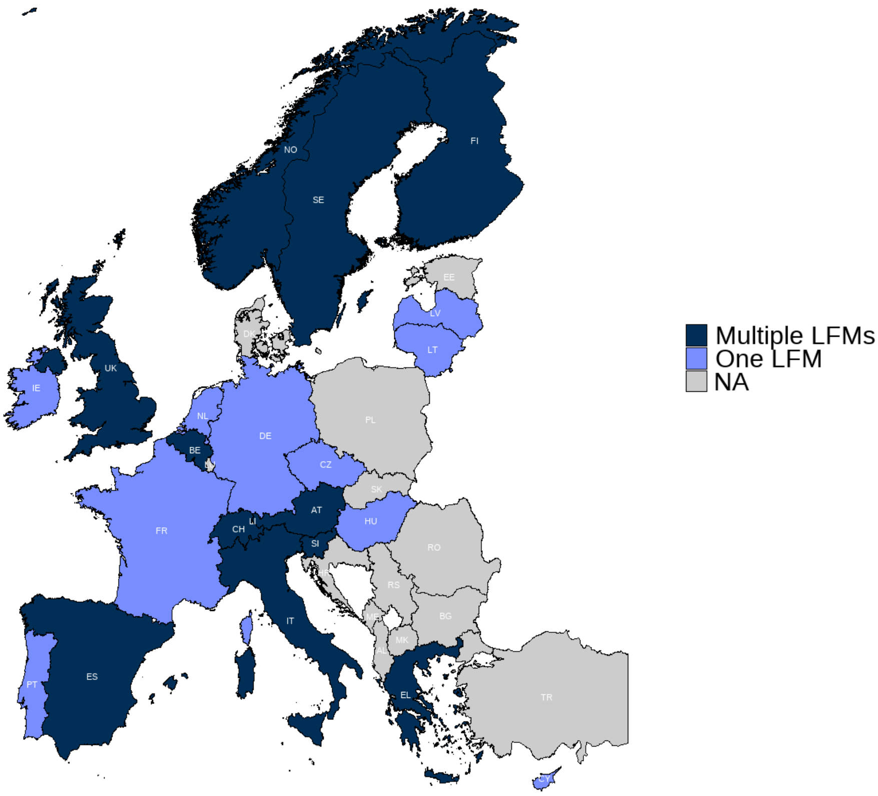


*Figure 0-1: Geographic coverage of LFM initiatives in the study (Source: own VITO figure).*

**General information LFMs:** Most LFMs are still in pilot or preparatory phases, reflecting growing interest in flexibility markets and the need for further learning and refinement. The majority are initiated by individual SOs seeking practical experience and manageable complexity. However, examples of TSO-DSO and multi-DSO cooperation are emerging, particularly where national or regional grid challenges call for joint approaches. The focus of most LFMs is on congestion management, with needs typically located at medium and high voltage levels. Flexibility procurement to solve low voltage needs remains more limited, due to monitoring challenges and localised complexities, although several initiatives are beginning to explore this area. LFMs use both in-house and commercial market platforms, reflecting - based on inputs from the surveyed LFM initiatives - a balance between the benefits of external expertise and rapid deployment and the need to retain operational control, while leveraging internal SO expertise.

**Product design LFMs:** LFMs tend to offer multiple products for the same service to address diverse flexibility needs and/or facilitate broad participation from diverse technologies. Simplicity and responsiveness to local conditions are very often prioritised over alignment with wholesale or balancing market products, although some initiatives demonstrate that national-level harmonisation can help achieve scale, liquidity, and improved integration. Active power products are the main focus, while reactive power products are rarely used due to technical complexity and liquidity challenges - though some mature LFMs show that under the right conditions, reactive power markets can be viable. Capacity procurement is common, often combined with energy products, as well as the option to submit free bids. Aggregation is widely allowed but constrained by technical and locational requirements.

**Market design LFMs:** The market design characteristics are structured according to the different market phases that can be distinguished, i.e., prequalification (PQ), procurement, activation, and settlement. The surveyed LFMs generally apply simple PQ requirements for service providers, focused on legal, administrative, and commercial eligibility; financial checks are rare. Product qualification rules tend to be minimal or under development. Grid PQ, the consideration of impacts on neighbouring grids, is limited. Around 80% of LFMs use a flexibility register, typically set up at the level of the LFM. In terms of procurement, procurement timings vary, with capacity often procured well in advance and energy closer to real time (day-ahead or intraday). For long-term (LT) procurement, tenders are very often used. Closed-gate auctions dominate for short-term (ST) procurement, while continuous markets are used in specific cases. Most LFMs use pay-as-bid pricing, and around 40% provide on indication on the SO willingness to pay to enhance participation. Activation is mostly manual, supported by automated activation signals. In terms of settlement, selecting appropriate baseline methodologies is considered challenging, with most initiatives supporting multiple approaches. Simpler methods are often preferred to encourage participation, while nomination baselines are used to allow Flexibility Service Providers (FSPs) to propose their own baseline. In some cases, capacity-limiting products are used to avoid baselines altogether. Penalties for non-delivery are uncommon at this stage, though some initiatives use pro-rata payment schemes or are developing penalty frameworks. The majority of LFM initiatives consider gaming risks minimal at this stage, with instances rare and often unintentional. However, limited monitoring and the immature stage of initiatives may mean some gaming behaviours go undetected, preventing a comprehensive risk assessment and highlighting the need for additional monitoring.

**Governance in LFMs:** Most LFMs operate as separate DSO-led markets, but interest in improved TSO-DSO and DSO-DSO coordination is growing, especially as markets mature and the need for harmonisation increases. Bid forwarding is not yet common but seen as a potential tool to enhance liquidity and coordination in the future. Information sharing practices differ significantly across LFMs. While most provide clear information on market rules and events, transparency on flexibility needs, value, and availability is still developing. There is, however, a clear trend towards increased transparency to support fair competition. Certain activities typically associated with market operation, such as matching bids and orders, and the final selection of bids are, in some cases within LFMs, carried out by the procuring SO, when an independent market operator (IMO) is present. Stakeholders stress the importance of neutrality, trust, and clear, harmonised processes, with recognition that new roles may emerge as LFMs evolve to meet future challenges.

### Key success features

The detailed analysis and evaluation of the LFM initiatives based on the proposed assessment framework enable the identification of key success features that can support the setup, evolution, and scaling of LFMs. Figure 0-2 presents a high-level summary of these success features. It should be noted that there is no one-size-fits-all LFM design; the success features are intended as general guidelines to guide initiatives toward the target LFM design in the medium term, which however can then be adapted to their specific context and needs. The success features are organized according to the main categories of the classification structure.

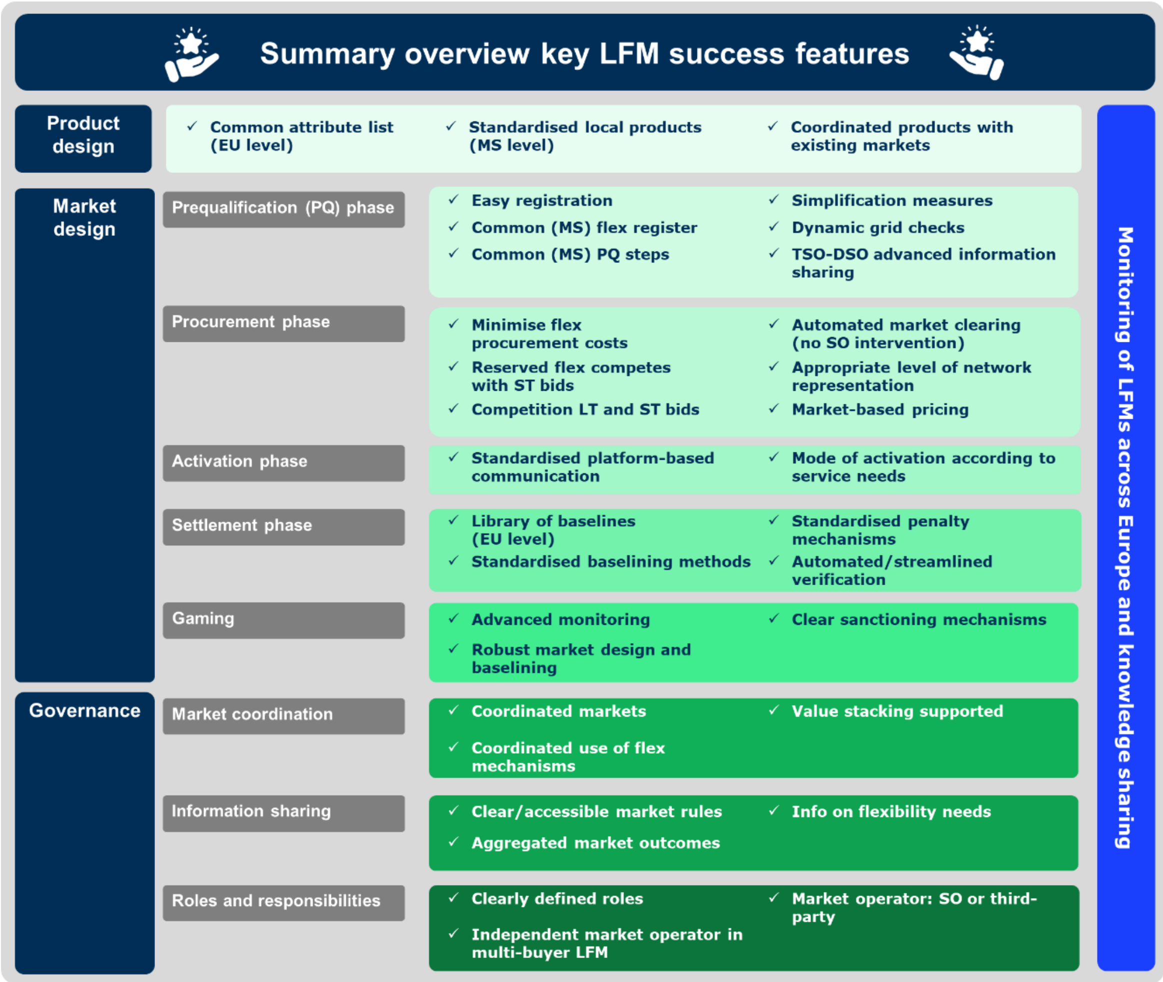


*Figure 0-2: Summary of key LFM success features (Source: own VITO figure)*

### Final recommendations

Our study has shown that many SOs, together with their partners, are still experimenting with LFMs. To urgently launch LFMs across Member States, we propose initiating simplified market designs to gain early experience and build confidence among key stakeholders, while simultaneously testing more advanced features that will enable the transition toward mature and ultimately harmonised markets. This will allow LFMs to be swiftly kick-started while supporting the transition toward a target LFM design as expertise, capabilities, market depth, and liquidity continue to develop. In parallel, further research and analysis are advised. We have identified several areas within LFMs where additional innovation and investigation are needed, including product design, qualification processes, market coordination approaches, baselining methods, aggregation models, and penalty schemes.

In the medium term, when markets are more mature, more harmonised approaches to LFM product and market design can then be pursued, building on the lessons learned in the coming years, while still allowing sufficient flexibility to accommodate local specificities where necessary. To support this harmonisation process, experience sharing and monitoring at the EU level are essential.
LFMs are not stand-alone solutions and should be fully integrated into the broader suite of flexibility mechanisms available to SOs. An integrated approach is required for both network planning and operation. This includes the trade-off between grid investments and flexibility, considering both implicit and explicit flexibility, for both DSOs and TSOs. To support this integration, the remuneration structure for SOs should be redesigned, and

robust methodologies should be developed to enable sound trade-off analyses for selecting the most efficient combination of solutions.

# 1 Introduction

## *1.1 Context*

As Europe advances towards a green and resilient energy transition, achieving the strategic goal of the European Union of a climate-neutral economy by 2050, requires the integration of a significant amount of renewable energy, including distributed energy resources (DER), into the electricity grid. Simultaneously, there is also a need for electrification in various end-use sectors such as heating, cooling, industry and transportation. These changes bring along many challenges linked to higher electricity consumption and increasingly fluctuating and decentralised generation, putting significant pressure on the electricity grids.

In response to this, the European Commission has published its Grid Action Plan in 2023 [1]. This plan emphasises that important efforts are needed at the distribution grid, as at this level, most decentralised energy resources are and will be connected, and as most changes in end-use behaviour (such as the adoption of heat pumps and electric vehicles) are expected here. In this respect, grid investments will need to be complemented with an **increased use of flexibility** to manage fluctuations in renewable energy generation and consumption, optimise grid investment costs, and ensure access to affordable energy for end consumers and the overall society.

In 2025, the European Commission launched the Competitiveness Compass for the EU and the Clean Industrial Deal (CID)[2]. As part of the CID, the importance of affordable energy and flexibility has been confirmed by the Affordable Energy Action Plan [3]. Moreover, at the end of 2025, the European Commission plans the launch of a European Grids Package [4] which will propose a set of legislative proposals to support the needed grid developments.

The electricity system is historically familiar with flexibility at the transmission level, primarily through the management of supply-demand imbalances using ancillary services, cross-border interconnections, and the dispatch of controllable generation units. However, to deal with challenges in the distribution grid, there is a higher need for distribution-grid-connected flexibility.

With rising DER levels and electrification at the end-use level, there are increasing flexible loads available at the distribution grid level. In past years, several important steps have been taken to unlock the potential of these new sources of flexibility. The European Commission recognised the **importance of demand-side flexibility** in 2009 with the adoption of the third energy package through the usage of the term demand-side management (Directive 2009/72/EC [5]). With the Clean Energy package [6], the pivotal role of end-use sectors was further highlighted. Next, the Electricity Market Regulation (2019/943) [7] and Electricity Market Directive (2019/944) [8] place consumers at the forefront of the energy transition by including various provisions aimed at facilitating the implementation of Demand Response (DR) mechanisms and their participation to the electricity markets.

In particular, Article 59(1), point (e) of the Electricity Market Regulation, empowers the Commission to establish a Network Code on Demand Response (NC DR). Article 32 of the Electricity Market Directive specifically states that Member States shall provide the necessary regulatory framework to allow and provide incentives to distribution system operators (DSOs) to procure flexibility services, including congestion management in their areas, in accordance with transparent, non-discriminatory and market-based procedures unless the procurement of such services is not economically efficient or would lead to severe market distortions or to higher congestion. As part of this process, the European Commission sent an invitation to ACER (June 2022) to launch a scoping exercise for the development of a NC DR. In December 2022, ACER submitted a non-binding Framework Guideline on Demand Response (FGDR), setting out clear and objective principles for the development of the NC DR [9]. The development of this network code is currently underway. In June 2024, EU DSO Entity and ENTSO-E submitted a joint proposal for the NC DR to ACER. ACER submitted its final proposal for a new EU-wide NC DR to the European Commission on 7 March 2025 [10].

Once the NC DR is adopted, it will become legally binding. However, as there is a lot of diversity between and within the different countries in terms of type of grids, maturity of (local) flexibility markets, RES penetration and energy mix, level of digitalisation, size of Flexibility Service Providers (FSPs), grid flexibility and investment needs, electrification of loads, etc., the NC DR leaves room to fill in certain flexibility market design characteristics individually per Member State, as part of the national TCs for baselining methods, for service providers for local services (including the rules for market-based procurement of local services), for a flexibility information system and for TSO-DSO and DSO-DSO coordination. This is because LFMs are difficult to standardise across countries with such diverse characteristics.

LFMs are emerging markets, and they exhibit different degrees of maturity all over Europe. Today, many LFM initiatives are still in a research phase. While there are already successful examples of actual flexibility procurement through an LFM, other initiatives still face numerous challenges to set up, implement, and/or run their local market. In addition, while LFMs are increasingly receiving attention, there is still a lack of comprehensive overviews and practical guidelines on the appropriate design for these markets. To support Member States in setting up their LFMs, it is important to have a framework that guides them in the design, implementation, and integration of LFMs at a local level, while considering conditional factors that influence local decisions and ensures a smooth integration in the overall energy system.

## *1.2 Objectives*

The general objective of the study is therefore to:

> ***General objective***
>
> *"Propose a design, implementation and integration framework to enable efficient market-based procurement of flexibility at a local level"*

To serve as a unifying framework for different Member States, the study will show how LFMs can be structured to maximise their benefits for the electricity system and, ultimately, for consumers. This involves a) addressing governance issues, i.e., defining the roles and responsibilities of various stakeholders, including options for coordination, b) focusing on design aspects such as products, timings, and market processes to maximise value stacking, i.e., providing opportunities to derive revenue from multiple markets and c) ensuring that these LFMs are well integrated into the current market setting, including the relation with other markets and flexibility mechanisms.

Specific attention will be paid to the appropriate level of harmonisation of flexibility products, the markets where they are traded and supporting processes, as on the one hand further harmonisation can bring certain benefits for the different stakeholders involved (decreased market entry costs, increased value stacking potential, increased market liquidity), but a too strict level of harmonisation can lead to market designs which are not fit for purpose or not suited for the local context and conditions.

As mentioned before, a number of initiatives and projects have focused on the design and implementation of LFMs, ranging from actual LFM implementations, demonstration projects of LFMs, policy studies, and academic research on LFMs. The study will assemble and assess the learnings and further insights from all these different sources of information in a structured manner.

The general objective is therefore further divided into three specific objectives representing these different aspects and sources of information, which also show the main structure of the study that will be covered by the different tasks.

**Specific objectives**

1. *Analysing the design and implementation features of current local flexibility market initiatives, as well as existing academic and policy research in this domain.*
2. *Assessing various alternative market designs and associated roles and responsibilities and identifying best practices based on adequate criteria.*
3. *Formulating key success features and recommendations for local flexibility markets to assist Member States in their implementation efforts.*

The main results of the study will thus be the formulation of design principles and recommendations for LFMs, which can be used as an input for Member States to develop their national terms and conditions, as would be requested by the future NC DR, based on their specific local context.

The following figure (Figure 1-1) provides a concise overview summarising the scope and objectives of the study.

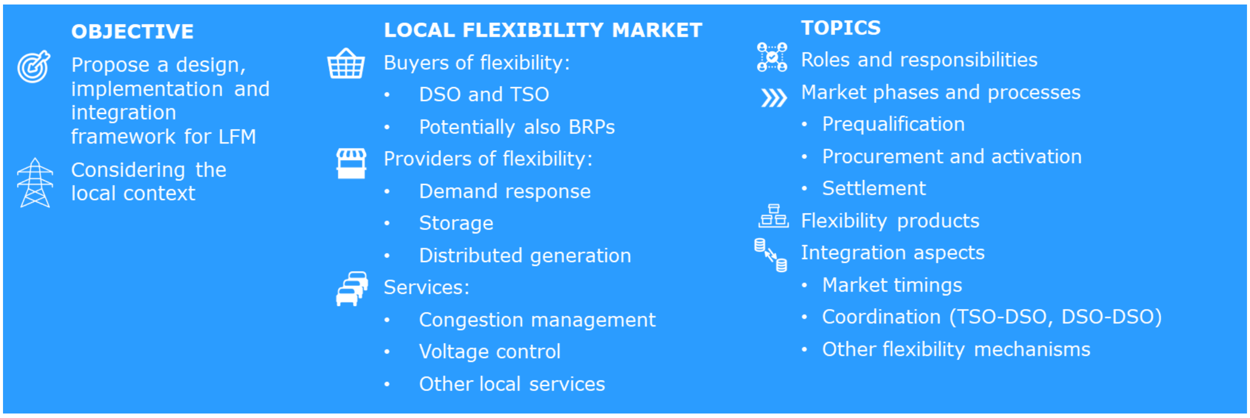


*Figure 1-1: Summary of the scope and objective of the study (Source: own VITO figure)*

## *1.3 Methodology*

To achieve the goals of the study, the work was divided into 5 tasks. The five tasks and their interconnections are visualised in Figure 1-2. The first two tasks run in parallel, followed by tasks 3 and 4, while task 5, is a transversal task linked to all other tasks.

**Task 1 Research and identification of projects for LFM** involves identifying and analysing relevant LFM initiatives and associated literature. As part of subtask 1.1, LFM initiatives are identified through desktop research, as well as by engaging with DSO/TSO associations and National Regulatory Authorities (NRAs) across the EU27 via a brief survey. In addition to these stakeholders, commercial (market) platform providers were also contacted. To support a structured analysis of LFM initiatives, a comprehensive LFM classification framework was developed in subtask 1.2. This contains LFM design characteristics structured according to four primary categories of information: general information, product design, market design, and the governance structure. In subtask 1.3, the LFM initiatives, as well as the identified literature (from subtask 1.1), are mapped to the classification framework developed in subtask 1.2. For each LFM initiative, a summary profile is provided in the form of an LFM identification (ID) card.

The mapping of the initiatives is a first step that enables their further assessment, which is carried out using a structured assessment framework. The development of this assessment framework is the goal of **Task 2 Definition of assessment criteria**. To this end, in subtask 2.1, we first determine key objectives that LFMs should meet, where these objectives are based on overall EU policy objectives as well as on general fundamental design principles for efficient and well-functioning markets. Then, in subtask 2.2, we introduce key assessment criteria to meet these objectives, coupled with a set of indicators allowing us to capture the level, up to which an initiative has met a defined criterion.

The developments within Task 1 and Task 2 set the stage for **Task 3 Identification of key features of successful LFM**. Indeed, subtask 3.1 aims at assessing each of the identified relevant LFM initiatives based on the developed set of assessment criteria and their relevant indicators. Next, in task 3.2, based on a thorough analysis of the assessment of subtask 3.2, we extract successful features of LFMs considering different factors such as market liquidity and maturity. The analysis of subtask 3.2 is then used in subtask 3.3 to identify key success features of LFMs, organised according to the categories of the classification structure.

This assessment then enables us to devise concrete recommendations, which is the goal of **Task 4 Specific recommendations on the design and implementation of LFM**. In this respect, first, in subtask 4.1 we will identify the regulatory context that can directly impact flexibility procurement by SOs and the set-up of successful LFM initiatives. Then, informed by this regulatory analysis, subtask 4.2 provides specific recommendations on the design features and implementation of LFMs, considering the regulatory context at the EU level. Subtask 4.3 will then summarise all findings in a structured overview.

As visualised in Figure 1-2, we use two core methodological approaches by combining desktop research (technical reports and academic literature) with stakeholder consultations. The **stakeholder consultations** take place in **Task 5**, which is a transversal task providing information and support to the different tasks. The objectives of the stakeholder consultation activities are to assemble detailed inputs on LFM initiatives, challenge our findings and ensure the validity of our recommendations. The following consultation activities are covered: i) structured interviews/surveys targeted to LFM initiatives and commercial platform providers (task 1); ii) two stakeholder workshops to collect information on the analysis of LFM research and initiatives, one for (market) platform providers and one for SOs (task 1); iii) targeted interviews with certain relevant stakeholders (subtask 3-4) and iv) one validation and dissemination workshop to share the main results of the study to a wider audience (all tasks).

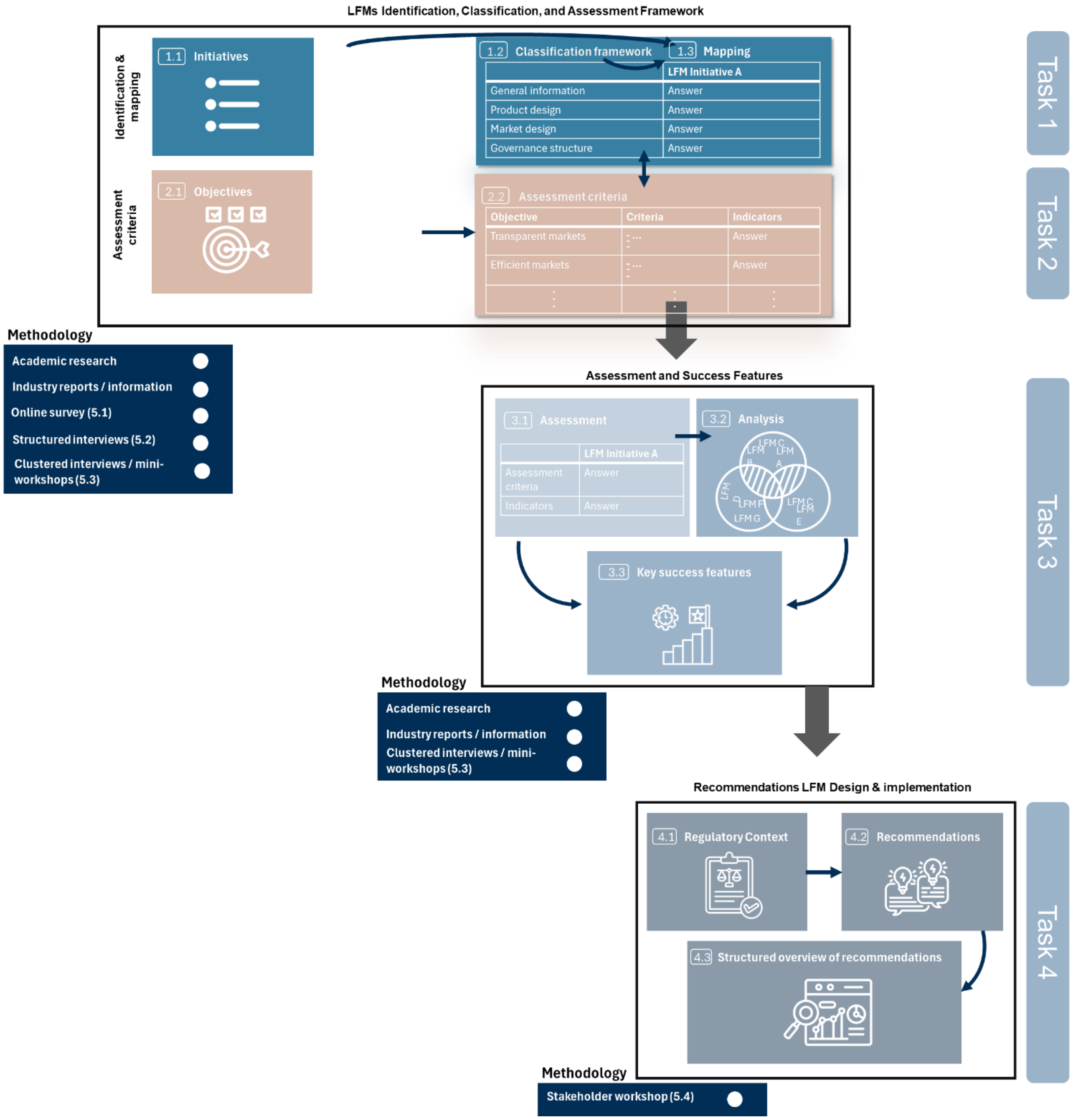


*Figure 1-2: Overall detailed project approach*

### *1.4 Structure of the document*

The document is structured to guide the reader through the analysis, assessment, and recommendations concerning LFMs. Following the introduction, which outlines the context, objectives, methodology, and structure, Chapter 2 provides a comprehensive analysis of LFM initiatives according to the classification structure, including general characteristics, product and market design features, and governance aspects. Chapter 3 presents the assessment framework and applies it to the identified initiatives, structured around key objectives reflecting EU policy priorities and market design principles. Chapter 4 synthesises the key success features of LFMs, organised according to the classification structure. Finally, Chapter 5 delivers the study's recommendations, offering guidance for policy makers and stakeholders to support the design and implementation of LFMs. The document is complemented by annexes providing a detailed overview of the classification structure with the definitions of its underlying components (Annex 1), a detailed overview of the surveyed LFM initiatives and platform providers (Annex 2 and 3), and the assessment framework (Annex 4).

# 2 LFM classification and analysis

In this chapter, we zoom into the 37 LFM initiatives that were analysed in this study. In section 2.1, we list the different initiatives. In section 2.2 we explain the classification structure that we developed to collect and analyse information on these initiatives, followed by the analysis of the 37 LFM initiatives for each of the topics.

However, before starting, we will provide a formal definition of what an LFM entails in this study.

> ***Definition Local Flexibility Market***
>
> *Local Flexibility Markets (LFMs) are markets where local services are traded, to address grid-related needs. The buyers of these services are Distribution System Operators (DSOs) and Transmission System Operators (TSOs).*
>
> *Local services refer to any service with a distinctly local character. LFMs are mostly applied in the context of congestion management and voltage control, but other services with a local character for which local flexibility markets are set up, are also considered in scope of our study.*
>
> *Both markets where local services are procured in dedicated markets as well as through bids in other wholesale markets (day-ahead, intraday, balancing) are considered LFMs.*

The chosen definition aligns closely with the definition of a local market in ACER's proposal for a NC DR [10], i.e., "a local market means the entirety of institutional, commercial, and operational arrangements that establish market-based procurement of local services." The draft NC DR further specifies that a local service refers to energy or capacity provided to a TSO or DSO to resolve intra-zonal physical congestion or voltage issues, and a local product is a product for the market-based procurement of such local services.

Based on this definition, we apply a set of criteria to select the LFM initiatives relevant to this project and to be analysed in detail. Given that the research and implementation of LFMs are still at an early stage, we do not filter initiatives based on their maturity. Instead, we focus on the scope of the initiative. The following filters are applied:

- Does the initiative focus on **market-based procurement**?

  A broad definition of market-based procurement is used, aligned with ACER's proposal for a NC DR [10]: "a procurement process for a service provision where either the selection of the service providers or the activation of the service is based on a bidding process." Both long-term (LT) and short-term (ST) procurement are considered in scope.

- Does the initiative include **at least one local SO service**?

  As previously explained, local SO services include congestion management, voltage control, or other local services identified by the initiatives.

- Does the initiative **consider flexibility from distributed resources**?

  Distributed resources refer to assets connected to the distribution grid, including demand (load), storage, and generation.

All initiatives included in this study meet these three criteria. In what follows, we present the different initiatives.

## *2.1 Overview of LFM initiatives*

This study covers 37 LFM initiatives which shared their insights and market design through written surveys and/or interviews. A first list of these LFM initiatives was collected based on expert inputs and desktop research. In addition, we reached out to DSO/TSO associations (ENTSO-E, E.DSO, EU DSO Entity, CEDEC, GEODE) and NRAs of the different EU27 countries through a brief survey. Aside from these two groups, we also contacted commercial market platforms (i.e. ELECTRON, NODES, EPEX SPOT, N-SIDE, EQUIGY, OMIE, GME, PICLO and GOPACS) as they are well-aware of the initiatives that use their platforms. We started our in-dept analysis by first focusing on the commercially available platforms and understanding their product offering and the degrees of freedom in the market rules they support. Next, we analysed their effective implementation in different LFM initiatives in different countries together with the other initiatives that developed their own in-house market platform.

This section presents an overview of the 37 LFM initiatives considered as part of the study. The map in Figure 2-1 provides a broad overview of all the countries covered in the study, along with the number of LFM initiatives for which responses were received. **Dark blue countries**, are countries in which we examined multiple LFMs. **Purple countries**, are countries in which we examined one LFM. All these countries and their corresponding LFM initiatives included in the study are discussed in the sections below. **Grey countries**, are countries that were not part of this study[1].

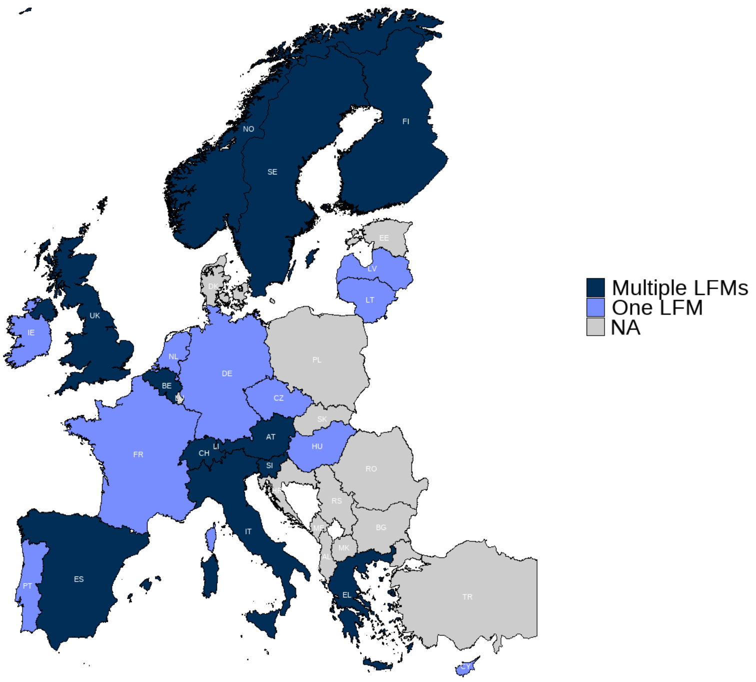


*Figure 2-1: Geographic coverage of LFM initiatives in the study (Source: own VITO figure).*

Table 2-1 gives a general overview of the 37 initiatives accounted for in this study. In addition, the column 'Country DSO concentration' is completed based on insights from [11] with the following explanations: **Very high** - One DSO company; **High** - One dominant DSO (more than 80% of distributed power) and several local DSOs; **Medium** -

[1] It should be noted that this study does not offer a comprehensive overview of all LFM initiatives within Europe; rather, it aims to present a representative sample.

A mix of DSOs, with the three largest accounting for more than 60% of distributed power; **Low** - Mainly small, local DSOs, the three largest DSOs usually deliver less than 50% of distributed power.

In Annex 2, readers who search more details on the individual LFM initiatives, can find so-called ID-cards of each of them including relevant background information and their main characteristics, organised by country. Annex 3 provides an overview of the various (market) platform providers interviewed during the study.

Finally, as discussed in the methodology section, some selected topics were further discussed during workshops with SOs and platform providers. In the workshop of the SOs, 4 TSO representatives and 30 DSO representatives participated, representing in total 27 different SOs. In the workshop of the platform providers, 18 representatives of 8 platform providers participated. The inputs of the participants during these workshops, is also integrated in this chapter.

*Table 2-1: Overview of LFM initiatives which are part of the study (Note: CM = congestion management; VC = Voltage Control).*

| Country | Initiative | Status | Flexibility service | Flexibility buyer | Market model | Country DSO concentration |
|---|---|---|---|---|---|---|
| **Austria** | Industry4Redispatch | Pilot (finalised) | CM | TSO only | Separate TSO LFM | Low |
| **Austria** | Step 1: Systemführung 2.0 (SF2.0) | Live market (in preparation) | CM | DSOs and TSO | Common market | Low |
| **Belgium** | Fluvius Reactive Power Market | Live market (in operation) | VC | DSO only | Separate DSO LFM | Low |
| **Belgium** | Fluvius Active Power Market | Live market (in operation) | CM | DSO only | Separate DSO LFM | Low |
| **Belgium** | ORES LFM Pic@u | Pilot (in preparation) | TBD | DSO only | LFM | Low |
| **Belgium** | SCOPE | Pilot (in preparation) | TBD | DSO only | P2P market | Low |
| **Cyprus** | Cyprus OneNet pilot | Pilot (finalised) | CM | DSO only | Separate DSO LFM | Very high |
| **Czech Republic** | Czech Republic OneNet pilot | Pilot (finalised) | VV | DSO only | Separate DSO LFM | Medium |
| **Finland** | FinFlex | Pilot (in operation) | CM | DSO and TSO | Sequential market | Medium |
| **Finland** | OneNet Northern Demonstration Finland | Pilot (finalised) | CM | DSO and TSO | Common market | Medium |
| **France** | Appel d'offres pour des Flexibilités Locales marché | Live market (in operation) | CM | DSO only | Separate DSO LFM | High |
| **Germany** | Augsburg LFM | Pilot (in preparation) | CM | TSO only | TBD | Low |
| **Greece** | Opentunity Greek demo | Pilot (in preparation) | CM, balancing | DSOs and TSO | Common market | Very high |
| **Greece** | HENEX Greece FEVER demo | Finalised simulations | CM, VC | DSO only | Separate DSO LFM | Very high |
| **Hungary** | Flex.on Local Flexibility Market | Pilot (in preparation) | CM | Multiple DSOs | Common market | Medium |
| **Ireland** | Irish Demand Flexibility Product | Live market (in preparation) | CM | DSO only | Separate DSO LFM | Very high |
| **Italy** | EDGE | Pilot (in operation) | CM | DSO only | Separate DSO LFM | High |
| **Italy** | RomeFlex | Pilot (in operation) | CM | DSO only | Separate DSO LFM | High |
| **Italy** | MindFlex | Pilot (in operation) | CM | DSO only | Separate DSO LFM | High |
| **Latvia** | LATVIA OneNet pilot | Pilot (in preparation) | CM | DSO only | Separate DSO LFM | High |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Lithuania** | Lithuanian OneNet LFM | Live market (in preparation) | CM | DSO only | Separate DSO LFM | High |
| **Norway** | Smart Senja | Pilot (finalised) | CM, VC | DSO only | Separate DSO LFM | Low |
| **Norway** | Euroflex | Live market (in operation) | CM, balancing | DSOs and TSO | Sequential market | Low |
| **Portugal** | FIRMe | Pilot (in operation) | CM | DSO only | Separate DSO LFM | High |
| **Slovenia** | Fleksibilnost Elektro Ljubljana | Live market (in operation) | CM | DSO only | Separate DSO LFM | Very high |
| **Slovenia** | Elektro Primorska STREAM pilot | Pilot (in preparation) | CM | DSO only | Separate DSO LFM | Very high |
| **Spain** | Spanish Regulatory Sandbox (OneNet, BeFlexible, FLOW) | Pilot (in preparation) | CM | DSO only | Sequential market | Medium |
| **Spain** | Local Flexibility Market in Anĕll's grid | Pilot (finalised) | CM | DSO only | Separate DSO LFM | Medium |
| **Sweden** | E.ON Energy Networks Sweden | Live market (in operation) | CM | DSO only | Sequential market | Low |
| **Sweden** | Sthlmflex | Live market (finalised) | CM, balancing | DSOs and TSO | Sequential market | Low |
| **Sweden** | Effekthandel Väst | Live market (in operation) | CM | Multiple DSOs | Separate DSO LFM | Low |
| **Switzerland** | Swiss Opentunity Demo | Pilot (in preparation) | CM | DSO only | Separate DSO LFM | Low |
| **Switzerland** | TSO-DSO Coordination (TDC Switzerland) | Live market (in preparation) | CM, VC | DSOs and TSO | Common market | Low |
| **Switzerland** | Parity Swiss pilot | Pilot (finalised) | CM | DSO only | P2P market | Low |
| **The Netherlands** | GOPACS | Live market (in operation) | CM | DSOs and TSO | Common market | Medium |
| **UK** | UKPN Local Flexibility Market | Live market (in operation) | CM | DSO only | Separate DSO LFM | Medium |
| **UK** | BiTraDER | Pilot (in preparation) | CM | FSPs | P2P market | Medium |

## *2.2 LFM Classification and analysis*

To systematically gather information on and analyse the LFM initiatives and commercial (market) platforms, we have developed a classification framework to collect information in a structured manner with the aim to present in an objective way how the surveyed LFMs are set-up today, including the justification or reasoning for the design choices. The classification framework contains LFM design characteristics structured according to **four primary categories** of information: **general information**, **product design**, **market design**, and the **governance structure**. Figure 2-2 gives an overview of the sub-categories within these primary categories. Annex 1 gives a more detailed description, with definitions of each of these sub-categories.

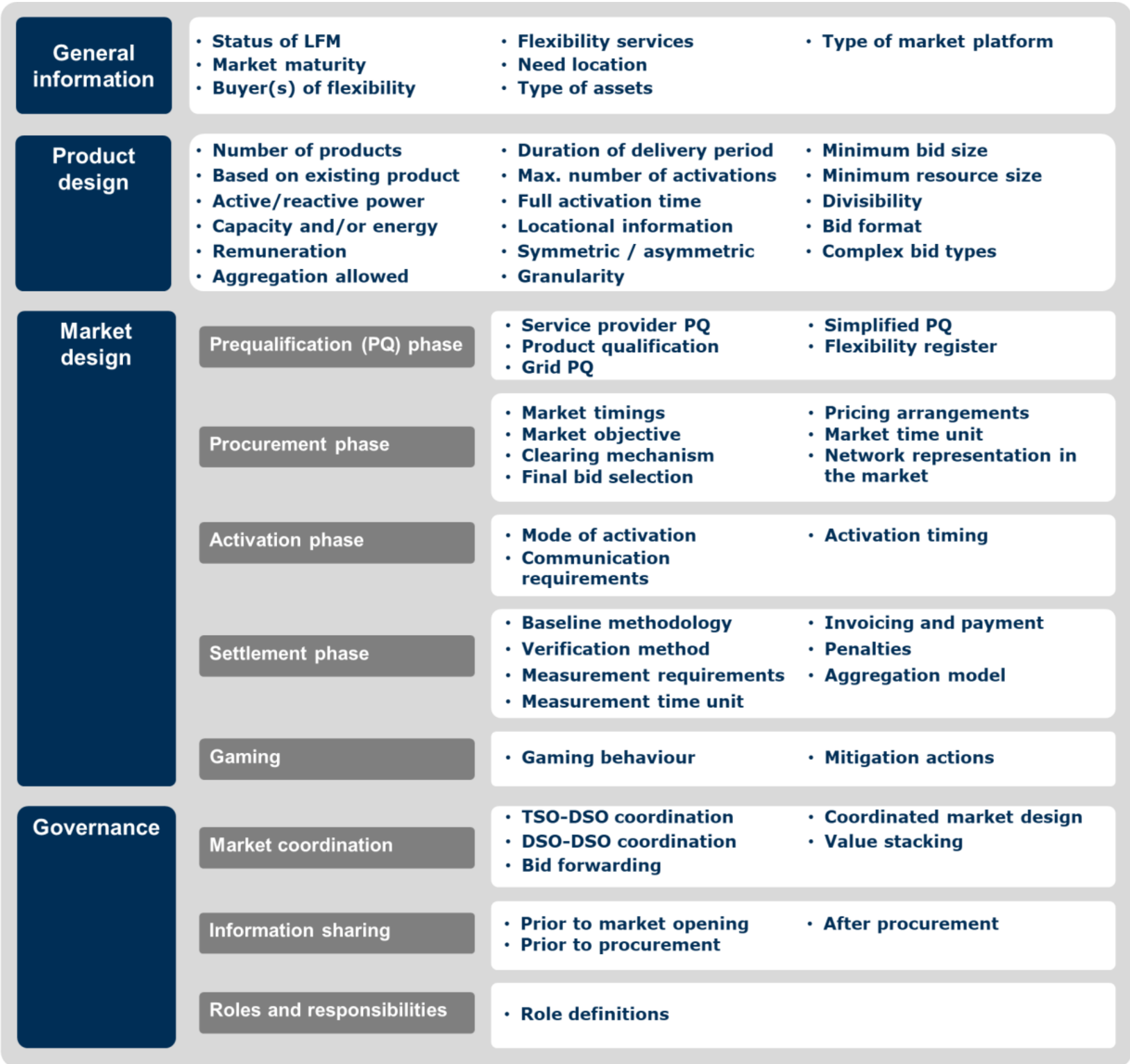


*Figure 2-2: Overview classification structure (Source: own VITO figure).*

The general information category will collect information on the general context, such as the status of the LFM, the type of grid on which the market focuses, the services traded, the buyers of flexibility, and the type of flexible resources or assets that participate in the LFM. The second category, the product design category, includes some of the main product attributes that can be used to define products for local services. These are, for instance, linked to timing aspects, minimum requirements, the remuneration mechanism of the flexibility, and how locational information is considered. The third category focusses on the market design where we not only cover the procurement phase, but also the other relevant supporting market phases, i.e., prequalification (PQ), activation, and settlement. The fourth category focuses on governance, addressing coordination aspects between SOs and with other existing markets. It will also consider the main roles and responsibilities, as well as information-sharing practices, across the different LFMs.

In the remainder of this chapter, we will introduce the design characteristics considered in this study, define them, and elaborate on the different options that could be chosen for each LFM design characteristic, drawing from the literature. Then, we provide a detailed analysis of the design elements of the 37 LFMs, highlighting the design choices - defined in the classification structure (see Annex 1)- adopted across the different LFM initiatives.

*It should be noted that not all maps and figures contain data of the same number of initiatives. In some cases, we might count characteristics of products (and given the fact that some initiatives have multiple products, there can be more observations than the number of initiatives). Furthermore, in some cases, initiatives have not decided upon all design characteristics discussed in the survey or the topic might simply not apply to their pilot (implying less observations than the number of surveyed LFM initiatives).*

### *2.2.1 General information*

For this first category of the classification structure, we collect general information on the different LFM initiatives.

**Status of LFM**

We distinguish between pilots and live markets. A pilot is typically limited in duration and is a trial run of the LFM before actual implementation. A live market entails actual procurement of flexibility by the SO via the LFM. In addition, we indicate whether the pilot or live market is in preparation, in operation, or inactive.

Insights from the surveyed LFMs
Most LFMs today are still in the piloting or preparatory stages, reflecting both the increasing interest in LFM and the ongoing need for learning and refinement.

As visualised in Figure 2-3, this study covered a broad range of initiatives. Most of the surveyed LFM initiatives can be classified as pilots (green colours). Those pilots are used to test an initial market design, improve the products, get FSPs acquainted with the idea of flexibility procurement, adapt regulation or give regulatory advice. Pilots are initiatives focusing on real-life implementations at a pilot stage, as well as research projects or demos from national or European research projects. Only 7 surveyed LFMs have real operational live markets where flexibility procurement is part of the daily operations (blue colours). Those are located in the UK, France, Sweden, Slovenia and the Netherlands as can be seen in the figures below. One of the inactive live markets is the SthlmFlex initiative which was a live market, but which is not operational anymore. The other one is the Lithuanian LFM. This market is prepared in theory and is ready to kick-off, however, there are no congestion requirements yet, explaining the market remains inactive for now.

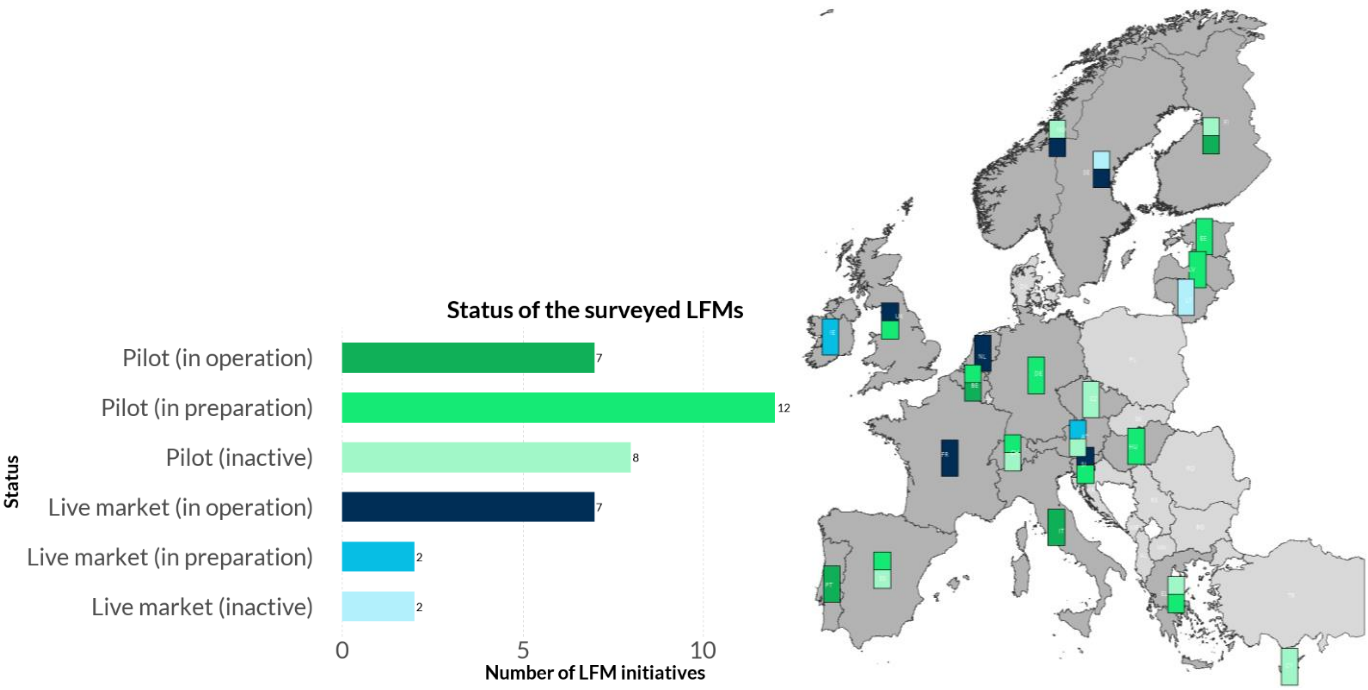


*Figure 2-3: Status of the surveyed LFM initiatives (Source: own VITO figure).*

**Market maturity**

Linked to the previous characteristics, we also collect information on market maturity. This characteristic reflects how long the market has been active since its first opening or initial trade, indicating the number of years the LFM has been operational. It is important to consider this when assessing the various initiatives, as more mature markets may also be more stable and advanced in their product and market design, while less mature markets are likely still in a learning or development phase.

Insights from the surveyed LFMs
The level of experience varies across LFMs, with mature initiatives showing longer lifetimes and a growing number of new initiatives emerging. However, apparent maturity levels may not reflect underlying expertise, as some LFMs build on mature systems despite short runtimes.

Figure 2-4 shows that initiatives with a live market in operation typically have more than three years of experience. In contrast, pilot projects tend to have less than three years of experience, which is expected given their inherently fixed and limited duration. At the same time, it shows that more LFMs are currently being set up to gain experience.

Nevertheless, it should be highlighted that the maturity level indicated below is the running time of the market itself. However, it is plausible that the market benefits from previous expertise and experiences. For instance, the SthlmFlex live market, which is currently inactive, was active for a shorter period of time, but made use of a mature market platform that already exists for a longer time. The Lithuanian LFM was only tested in a pilot European project and is having less than a year of experience as the kick-off of the live market did not take place yet.

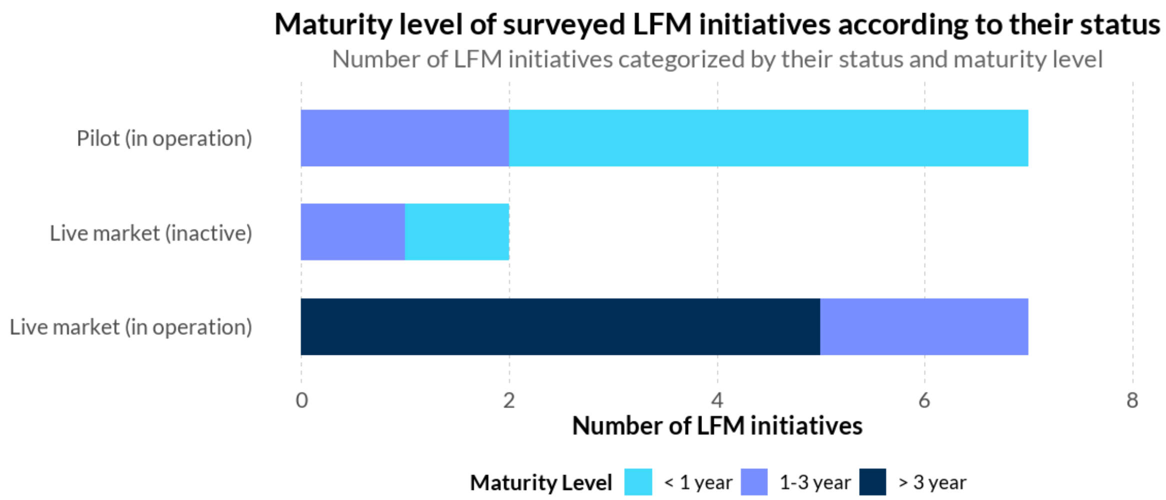


*Figure 2-4: Maturity level of surveyed LFM initiatives according to their status (Source: own VITO figure).*

**Buyer(s) of flexibility**

Different parties can procure flexibility through the market. As noted earlier, our focus is on local SO services, which can be procured by both DSOs and TSOs. As explained in [12], TSOs, DSOs, and commercial actors (such as BRPs) are all potential buyers of flexibility in a flexibility market context. They can decide to do this in a single-buyer or multi-buyer market model. The choice of having one or multiple buyers in an LFM influences the overall market model and potential coordination mechanisms between the DSO and TSO. This will be discussed in more detail in section 2.3.1. The same source also notes that, in the longer term, new and more decentralised models may emerge, in which peers or FSPs trade directly among themselves, while still providing a service to the SO. In such cases, FSPs act as both the sole buyers and sellers within the market. Such Peer-to-peer (P2P) LFMs have been demonstrated, for example, in the Swedish pilot of the CoordiNet project [13]. There, a P2P market platform was developed to initiate trading among consumers and producers in response to grid constraints communicated by the DSO, such as those occurring during maintenance events. This market mechanism allows FSPs to trade capacity between one another, either between both consumers and producers (as demonstrated in one region), or among producers only (as demonstrated in another region), thereby avoiding curtailment and resolving grid issues [14]. P2P markets when set up to solve a DSO need are therefore also in scope of this study.

<u>Insights from the surveyed LFMs</u>
Most LFMs are set up by an individual DSO, primarily to gain experience and manage complexity in early stages, though examples of TSO-DSO and multi-DSO cooperation exist, particularly where national or regional grid challenges support joint approaches. These initiatives illustrate growing interest in more integrated, standardised approaches as LFMs mature and coordination needs increase.

As visualised in Figure 2-5, in most initiatives, a single DSO establishes an LFM independently to procure flexibility. The bar chart and the map are highly dominated by DSO-only initiatives. However, in some cases, multiple SOs are involved.

Some examples of common initiatives can for instance be found in Finland where the surveyed initiatives involved both the DSO and the TSO setting up their LFM (OneNet Finnish demo and FinFlex). Similarly, in the Netherlands, GOPACS is uniting all DSOs and the TSO in one common market. In Austria, there are two key initiatives: they started with a TSO only market (Industry4Redispatch), but they are moving to a TSO-DSO market in which the DSO also procures flexibility (Systemführung 2.0 (step 1)). In Switzerland and Greece, there are two initiatives preparing a market with both the TSO and the DSO (Opentunity Greek demo and the Swiss TDC initiative). In the UK, even though there are mostly DSO-only markets, there is one initiative in which the DSO is actually setting up a P2P market in which FSPs trade curtailment obligations with other FSPs holding fixed connection agreements, in order to avoid being curtailed in the event of congestion. Similarly, in Belgium, ORES is kicking-off the SCOPE project, which is a secondary congestion option platform where exchanges will take place on a P2P basis between decentralised energy producers and flexibility providers. Furthermore, Hungary is setting up a platform in which multiple DSOs cooperate when procuring flexibility. Also in Norway, there is the EuroFlex initiative in which multiple DSOs are involved. In Sweden, there was the Sthlmflex initiative in which multiple DSOs and the TSO procured flexibility in a sequential setting and Effekthändel Väst in which multiple DSOs procure flexibility.

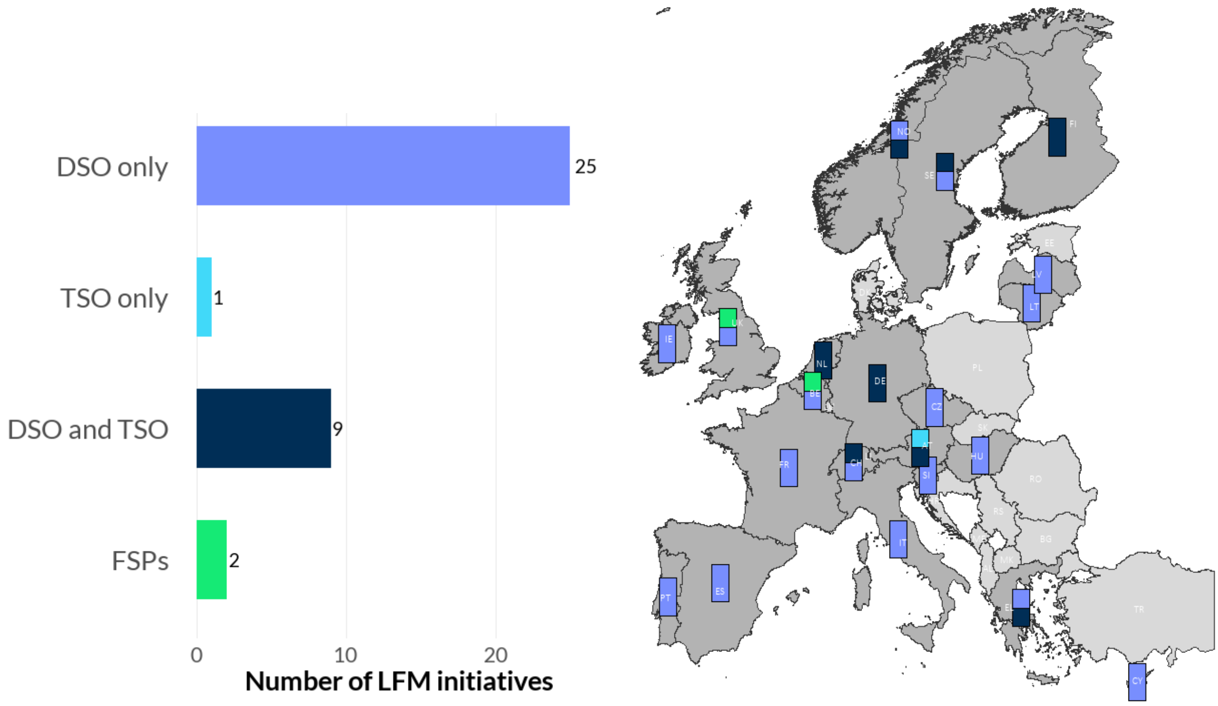


*Figure 2-5: Flexibility buyer in the surveyed LFM initiatives (Source: own VITO figure).*

The survey respondents provided several reasons why most markets in Europe are DSO-only, and why some markets involve multiple SOs.

- **Experimentation and gaining experience** – The majority of surveyed LFMs indicated that the main objective is to test the concept in practice (e.g. testing of the operational tools and processes, identifying market interest, defining a correct pricing mechanism, etc). One initiative explicitly noted that setting up a market, gaining experience and translating the learnings into new products, tools and processes takes time. To gain initial experience, many chose to start with a single SO, as even this proved challenging. In the short term, the involvement of multiple SOs would have likely increased the effort needed to establish a common understanding and agreement on governance, product and market design, and the overall complexity of these elements.

- **Differences between SOs** – In countries with multiple DSOs, potentially operating in regions that differ in language, grid characteristics, RES penetration, culture, geography, or even regulation, it is more tempting to set up an LFM without aligning with other SOs. In addition, even within the same country, for different DSOs, there can be strong differences in the roll-out of smart meters and the observability of the grid. Finding common ground is therefore not always easy, explaining why, in the same country, different individual market set-ups can be found. France is one of the countries where the LFM successfully was expanded over the entire country. One of the main explaining factors is that there is only one DSO who is responsible for more than 95% of the total distribution grids.

  The procurement of flexibility services by DSOs is a new responsibility and requires the set-up and preparation of new roles, processes and tools. This leads to examples of LFM market set-ups in 2 stages; for example, in Austria, one of the initiatives indicated that there was a high willingness to set up a TSO-DSO market in which both SOs would be procuring congestion management services. However, there was a difference in SO readiness and originally, the country therefore kicked-off with a TSO-only congestion management market. Nevertheless, this was done in close collaboration with DSOs, ensuring that many market and product specifications were already fit for both SOs. In a second stage, they are now moving to a new set-up of their market, involving both the TSO and the DSO.

  Individual DSO-only markets do not mean that there is no coordination between SOs. It can be a way to kick off swiftly in the short-run, to further scale up in the long-run. In the UK, there are many DSO-only markets, however, they all use the same set of standardised products and market design characteristics as specified by the ENA[2]. Sweden as well is striving to move towards more standardised products. Also in Spain, there is a significant amount of DSO-DSO coordination where OMIE - the Nominated Electricity Market Operator (NEMO) for Spain and Portugal - actively discusses with multiple DSOs, ensuring all DSO needs (e.g. technical requirements) are covered. As a result, and as further discussed in section 2.3.1, there is already a vision towards more integrated markets. In some countries, preparations are already being taken as many DSO-led LFM initiatives are currently in discussion with their TSO to improve coordination and alignment.

- **Severe grid challenges** – While some LFMs are being established as experimental initiatives to prepare for future grid challenges, others are already being set up to address real congestion problems. The Netherlands is one of the EU-member states where awareness linked to grid challenges is very high, driven by the actual

[2] Energy Networks Association (ENA) is a not-for-profit industry body representing the companies which operate the energy networks in the UK and Ireland. ENA facilitated the development of local flexibility markets in the UK by coordinating standardised processes, platforms, and procurement frameworks across network operators to enable the competitive sourcing of flexibility services from distributed energy resources. This is done through the Open Networks programme, which is ENA's strategic initiative that brings together all electricity network companies, the Electricity System Operator (ESO), the government, the regulator, and the wider industry. Driven by the government's Smart Systems and Flexibility Plan and supported by Ofgem, ENA is working to make the energy flexibility market easier to take part in, more coordinated, and more transparent. In 2023, all UK electricity networks gave signatures to restate their commitment to implement Open Networks' recommendations to ensure best value for market participants. The result of this process is a framework with three focus areas ("making it easier for FSPs to participate", "improving operational coordination between networks and companies", "improving the transparency of processes and reporting") in which different outcomes are defined. For the FSP focus area, the outcomes are linked to product standardization, PQ standardization, standardization of flexibility contracts and dispatch Application Programming Interface (API), and standardization of settlement processes. More information can be found through the following link: https://www.energynetworks.org/work/open-networks/ .

observed congestion problems in the grid. This has been an important enabler for the active development and upscaling of the GOPACS initiative.

**Flexibility services**

Different flexibility services can be procured via LFMs by SOs. In this study, both local services (congestion management, voltage control) and central services (balancing services) or a combination of both are considered. However, at least one of the services should be a local service to fit the definition of an LFM as presented above.

Insights from the surveyed LFMs
Most of the surveyed LFMs are set up to procure solutions for congestion management.

Figure 2-6 shows the services that are being procured through the LFM initiatives. LFMs are primarily set up to procure local SO services but centralised SO services could also be procured alongside local ones (e.g. balancing services). Note that in this figure, in case an initiative covers multiple services, this initiative is counted multiple times. As visualised in Figure 2-6, initiatives that are considering setting up an LFM or that have set up an LFM, are mostly doing so in response to a need to solve congestions. Only few initiatives aim to tackle voltage issues.

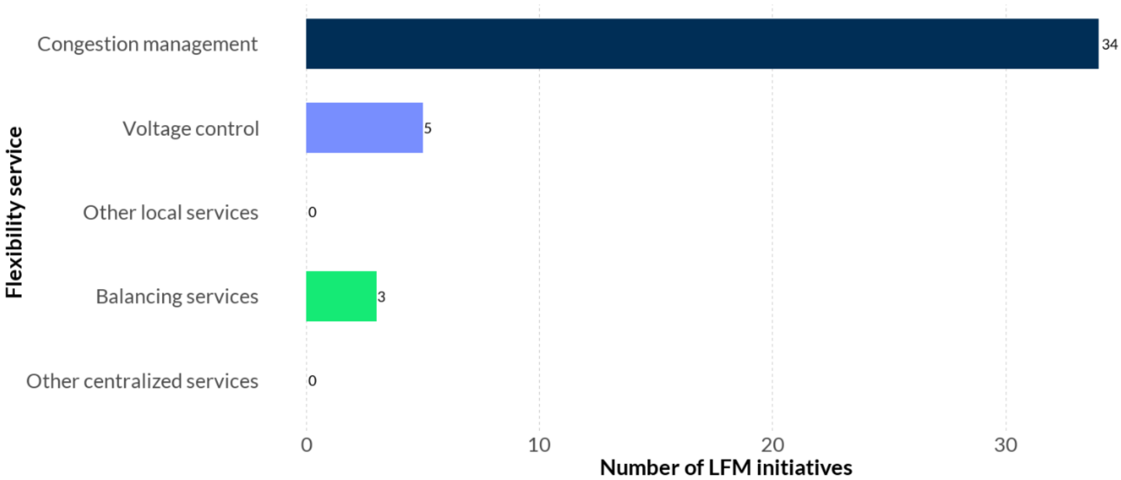


*Figure 2-6: Overview of flexibility services procured through the LFM initiatives (Source: own VITO figure).*

In total, in the figure above, 6 initiatives have been double counted as they look at a combination of multiple services. Three initiatives combine congestion management and voltage control, and three initiatives look simultaneously at congestion management and centralised services. One of them (the Greek OPENTUNITY demo) is still in preparation, one is the inactive live market Sthlmflex, and the third is Euroflex. It should be noted that, as will be discussed in section 2.3.1, some initiatives do allow for bid forwarding or value stacking. In the figure above, this is not counted as directly offering central services in addition to local services.

In summary, it can therefore be concluded that the majority of the surveyed initiatives focusses on local services, in particular congestion management because in some countries, DSOs and TSOs report increasing grid congestions. Alternatively, there are SOs without significant actual flexibility needs who aim to prepare themselves for the future by investigating if LFMs are the way to go, by creating awareness with stakeholders, by setting up pilots or regulatory sandboxes that can give input to the regulatory framework, and/or by developing a market platform.

### Need location

The need of the SO can be located at different voltage levels (Low Voltage (LV), Medium Voltage (MV), High Voltage (HV) or Extra High Voltage (EHV)), in different types of grid (meshed, radial or a combination) and in different portions of the network.

Insights from the surveyed LFMs
LFMs are typically set up to solve needs at MV and HV levels. Flexibility procurement to solve LV needs remains more limited, due to monitoring challenges and localised complexities, although several initiatives are beginning to explore this area. Nevertheless, several initiatives already procure (or plan to procure) flexibility at lower voltage levels to cover MV and HV needs.

Services are procured across a wide range of grid situations. In this section, we discuss the **location of the grid need** (the voltage level), the **network topology** (meshed, radial or a combination of both) and the **involved network segment** (transmission grid, distribution grid, or the interface between transmission and distribution grid). For voltage levels, we adopt the following classification: LV – up to 1,000 volts (1 kV); MV – above 1 kV up to 36 kV; HV – above 36 kV up to 230 kV; and EHV – above 230 kV. It should be noted that this classification may differ in practice across the surveyed countries; however, for the sake of comparison, we use this uniform classification for mapping the voltage ranges of the LFM initiatives.

r analysis showed that most services are procured to target issues in MV or higher levels in the surveyed LFM initiatives. This is illustrated by the graph below (Figure 2-7) which maps initiatives according to the grid levels for which they require flexibility. In case an initiative is active over multiple of these grid locations, it is counted multiple times in the figure below. Some initiatives have not yet decided in which locations and grid levels they will implement their LFM and are represented by the 'To Be Decided' (TBD) category. Due to the spread of voltage levels where the need is located, the surveyed initiatives report a mix of different topology types, representing both meshed and radial grids. When needs are located at lower voltage levels, radial grids are more common. Higher voltage levels report a mix of radial and meshed grids.

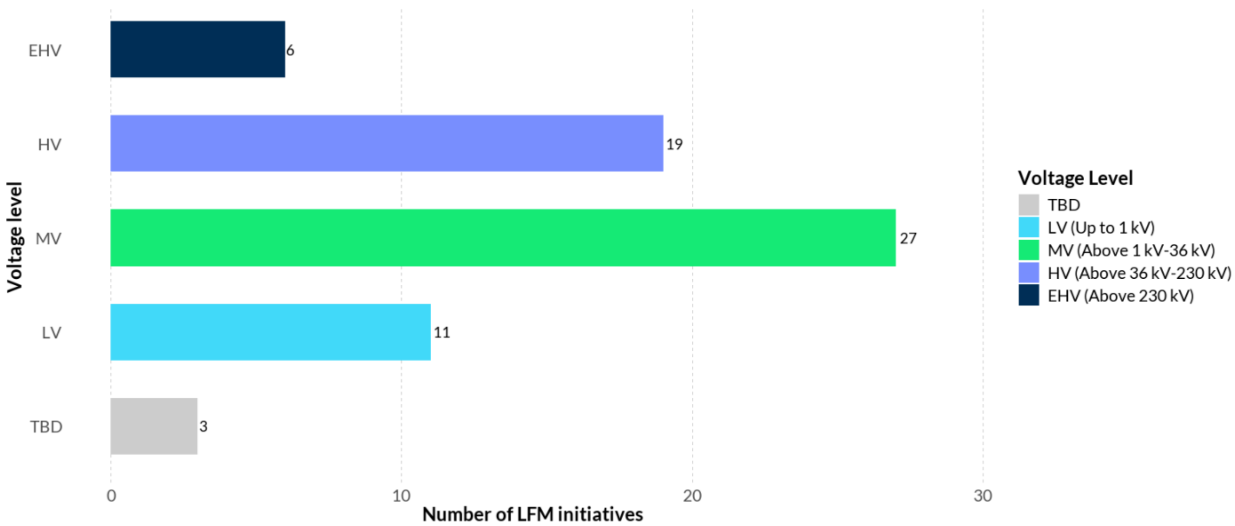


*Figure 2-7: Location of flexibility need in the surveyed LFM initiatives (Source: own VITO figure).*

Respondents gave a number of reasons why flexibility was more often procured for higher voltage levels. First of all, the **complexity** of market-based procurement of flexibility tends to increase at lower voltage levels, as the issues are, by definition, highly localised and the number of assets capable of addressing them is limited. Consequently, the majority of initiatives do not focus on market-based procurement of flexibility for addressing LV-level needs. Furthermore, the **flexibility need** was in some initiatives simply located primarily on MV and HV levels. Very often DSOs look at specific challenges at primary or secondary substations which are mostly relevant at higher voltage levels. However, it should be noted that today, congestion issues are not yet present in all surveyed countries and locations. In addition, in some countries, LV networks receive less focus due to the difficulty of **monitoring and controlling** smaller-scale flexibility in a market-oriented manner. This is especially the case in regions with a lack of smart meters and real-time monitoring infrastructure. However, the study shows that some countries have specific regulatory legacy systems at LV-level, allowing the DSO to control LV-assets, such as, for instance, electric boilers. Finally, it was argued that the impact of LV LFMs might be lower and not always technically feasible. Alternatively, other flexibility mechanisms, i.e. dynamic tariffs, Flexible Connection Agreements (FCA), might need to be considered in the case of LV needs.

**Type of assets**

Assets that can offer their flexibility to the LFM may be residential, commercial, or industrial. Furthermore, they can differ depending on whether they provide flexibility through consumption, generation, or storage.

Insights from the surveyed LFMs
Most LFMs allow participation from all asset types through aggregation, though practical barriers – such as managing small-scale LV resources, observability limits, and infrastructure needs - still hinder full access for LV-connected assets; some initiatives also permit planned assets to participate to the LFM, to foster innovation while managing associated risks.

The classification structure includes the types of assets allowed to participate in the LFM. This includes load, generation, and storage assets, with a further distinction between residential, commercial, and industrial categories. We also check whether the participation of all types of flexible resources is allowed and/or whether certain restrictions to market access apply, which potentially pose a barrier to technology neutrality.

In a majority of the surveyed LFM, all type of assets are allowed to participate in the market. This is mainly made possible by the fact that aggregation is allowed to offer flexibility (for more details, see section 2.2.2). However, some initiatives (less than one-third) do not explicitly allow for LV-connected flexibility assets: they explicitly target industrial or commercial assets or define a minimum asset size (see further discussion on product characteristics in section 2.2.2). Furthermore, in some cases, specific technologies such as EV charger hubs or large-scale generation, which are typically located at MV voltage levels or above, were targeted as part of the demo setting (for instance, in the Czech Republic OneNet pilot).

Nevertheless, although most of the LFMs do allow participation of all asset types, in practice, it becomes evident that there are still quite some practical barriers that make market access for LV-connected assets more challenging. First of all, there is the **complexity of managing many small-scale LV resources**. It is argued that the mathematical complexity, due to the combinatorial effects of many small bids, can be quite substantial, leading to optimisation problems and mathematical infeasibilities. For this reason, some initiatives set minimum bid and asset sizes, or they first experiment with larger assets before they include smaller assets. Furthermore, to offer specific services (such as reactive power), extending flexibility procurement to LV, would require additional investments in **metering infrastructure and grid monitoring**. Moreover, **observability** is sometimes more limited with smaller assets and consumers. Finally, LV consumers are not yet always aware of all the options of their flexible assets, and it might be hard to **engage** them. While LV flexibility is becoming more prevalent, aggregation is required to make it viable, and the market is still evolving to accommodate this. Most initiatives allow aggregation; however, the extent to which aggregation actually takes place can vary (for further discussion, see section 2.2.2).

Finally, to encourage innovation and market growth, certain LFM initiatives even accommodate 'planned' assets, resources not yet operational but expected to be available upon delivery, although this introduces risks for DSOs. To manage these risks, some DSOs impose limits on the share of planned assets an FSP may include, balancing the promotion of new entrants with system reliability.

**Type of market platform**

LFM initiatives can either deploy an in-house developed market platform, or they can make use of an existing platform from a commercial platform provider.

Insights from the surveyed LFMs
LFM initiatives adopt either in-house or commercial market platforms depending on their priorities, balancing the benefits of external expertise and rapid deployment with the need to retain operational control, while leveraging internal SO expertise. Coordination layers are sometimes added to link existing platforms and support TSO-DSO collaboration.

A final distinction made in this section concerns the type of market platform used, specifically, whether the LFM initiative deploys an in-house developed platform or relies on an existing platform provided by a commercial market platform provider.

From Figure 2-8, it becomes clear that there is a mix of some initiatives that develop their own in-house market platform, and some that rely on an existing commercial platform. There does not appear to be a correlation between the status of the market initiative (pilot versus live markets) and the type of market platform chosen. About two-thirds of the surveyed pilots and live markets decided to work with a commercial market platform provider. Furthermore, it should be noted that there are also LFM initiatives that add an additional coordination layer on top of specific (existing) market platform solutions. For instance, as explained in the ID-cards of GOPACS and the Finnish OneNet demo, on top of existing markets (e.g. Nordpool in the Finnish demo and EPEX SPOT and ETPA for GOPACS) a coordination platform was built. In case of GOPACS, the goal of such a coordination platform was to ensure a level playing field for all market exchanges to join the Dutch congestion market. Furthermore, the GOPACS platform ensures coordination between DSOs and TSOs, allows both TSO and DSO to use flexibility available in each other's grid and ensures limits of the other grid operators are respected. In case of the Finnish OneNet demo, existing market platforms were connected to a TSO-DSO coordination platform which made the final procurement decisions. These decisions were then communicated back to the market platforms, which then concluded the trades.

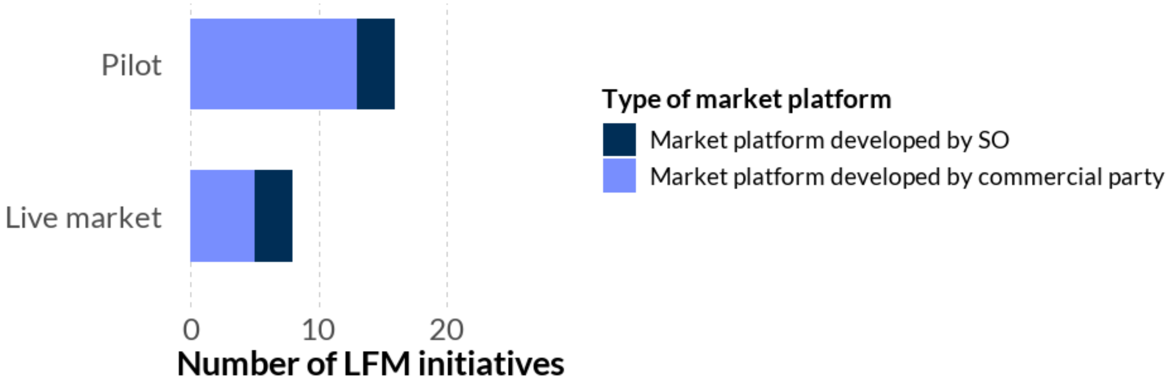


*Figure 2-8: Type of market platform used by the surveyed LFM initiatives (Source: own VITO figure).*

There are multiple, sometimes conflicting reasons why SOs choose to develop their own platform or why they opt to go for an existing commercial market platform. It is argued that implementing an existing (commercial) platform helps to **establish and test an LFM in a faster way**. Some initiatives also hope to **receive additional experience** by cooperating with platform providers that already have experience in setting up LFMs in different countries. They hope to receive some **guidance** in terms of product definition. Finally, not all SOs have **in-house expertise** to set up a market platform.

On the other hand, initiatives that already do have some internal system set-up, argued it is **convenient** to build further upon existing legacy systems and expand it for flexibility procurement, as such developing their own market platform. Furthermore, it was argued by some SOs that it is important for them to keep IT development of their platforms in house to **avoid dependencies for crucial SO responsibilities** and **prevent vendor lock in**. Some SOs caution that relying on commercial platforms can **unintentionally bias the design** of the flexibility market towards the functionalities, limitations and most commonly used practices/preferences of the platform itself.

### *2.2.2 Product design*

Defining the products to be traded in an LFM is one of the cornerstones of the market set-up. The product definition is grounded in the local services that the procured flexibility is expected to deliver. The technical requirements of these services (including their procurement and activation timing) would then shape the set of attributes that the products must have and the respective value of each of those attributes. The H2020 OneNet project [15] has defined a theoretical framework for the building of such products and their potential standardisation/harmonisation. Different levels of harmonisation exist where, in some cases, the product attributes are harmonised, but the values might differ, while in other cases both the attributes and their respective value are aligned.

A generic set of attributes resulting from OneNet is highlighted in Figure 2-9.

| | Objective of the product | | | | |
|---|---|---|---|---|---|
| | Technical dimensions | | | Bid related dimensions | |
| | The network operator aims to operate the network efficiently and reduce the overall cost of network operation and planning. To achieve this, the network operator will define technical requirements for the traded products and the market mechanism. | | | The bid related dimension of a flexibility product reflects the rules introduced in the bid as part of the procurement process. | |
| | Definition of the good traded | Timing for delivery | Communication | Technical rules for the bid | Settlement rules |
| | Characteristics of the "good" being acquired by the SO | Description of the timing in the delivery of the product | Methodology used to communicate between SO an FSP | Limitations in the structure of the product | Measures linked with the way that companies will be paid |
| Choices SO/MO do in attributes | Capacity / energy | Maximum preparation period | Required mode of activation | Minimum quantity | Baseline methodology |
| | Active/reactive energy | Maximum ramping period | | Divisibility (Y/N) | Measurement requirements |
| | Location information required (Y/N) | Maximum full activation time | | Granularity | Penalty for non-delivery |
| | Certificate of origin (Y/N) | Duration of delivery period | | Maximum and minimum price | |
| | Minimum level of availability | Maximum deactivation period | | Availability price (Y/N) | |
| | Symmetric/asymmetric product (Y/N) | Maximum recovery period | | Activation price (Y/N) | |
| | Validity period of the bid | Maximum number of activations | | Aggregation allowed (Y/N) | |

*Figure 2-9: Attributes of a genetic flexibility product [15]*

The definition of the product attributes must consider the service requirements but should also take into account reducing possible entry barriers by not introducing more stringent conditions than required. For example, The H2020 OneNet project [15], [16] has evaluated the possible barriers introduced by different product attributes for different flexibility sources.

Different approaches can be taken when defining products for local services when establishing or further evolving an LFM, which 1) either start from the specific SO/local grid needs and the available flexible resources, or 2) from existing product definition from other markets and/or for other services, e.g., DA/ID wholesale markets, other LFMs, or balancing products. A combination of approaches is also possible. In the H2020 EUniversal project [17], the first approach was followed and flexibility products (and attributes) were designed, starting from the identification of the individual SO needs and the related technical and operational requirements. In the H2020 Coordinet project [12], and similarly in the H2020 OneNet Project [15], the second approach was further developed aiming for a harmonised set of products, with common attributes, and being able to provide multiple services. In the northern demonstration of the OneNet project [18], the near real-time active energy product for congestion management was designed in a way closely similar to the manual Frequency Restoration Reserve (mFRR) product (more specifically for scheduled activation of MARI [19]) to enable potential flexibility participation of flexible resources not only in congestion management but also as part of MARI in a subsequent step. However, for other products, such as LT capacity products for congestion management, a specific product design was put in place to meet the needs of the procuring SOs and the local settings.

In the current section we analyse the products that are being traded on the surveyed LFM initiatives in more detail.

Following product characteristics are considered as part of the classification structure. A first element is the **number of products** which are being traded on the LFM. Next, we will classify the products based on several attributes - whether the product for the local service is **based on an existing market product**, whether it involves the procurement of **active or reactive power,** whether it is a **capacity or energy product** (and the associated **type of remuneration**), and whether **aggregation is allowed**. Additionally, we outline some commonly used **attributes for defining local service products**. For each attribute, we will assess whether the LFM initiative considers this attribute, and if yes, how they defined it (including the reasoning therefor).

**Number of products**

A first product design characteristic is the number of products which can be traded via LFMs.

Insights from the surveyed LFMs
Typically, for the same service, multiple products are available in the surveyed LFMs. Multiple product definitions in LFMs reflect efforts to address diverse flexibility challenges using targeted procurement formats and/or to facilitate broad participation from diverse technologies.

From the survey, it can be seen that the majority of the initiatives have defined more than one (generally 2 or 3) products in their LFM for one service (Figure 2-10). However, it is to be noted that a significant proportion of the surveyed LFM initiatives only defines one product.

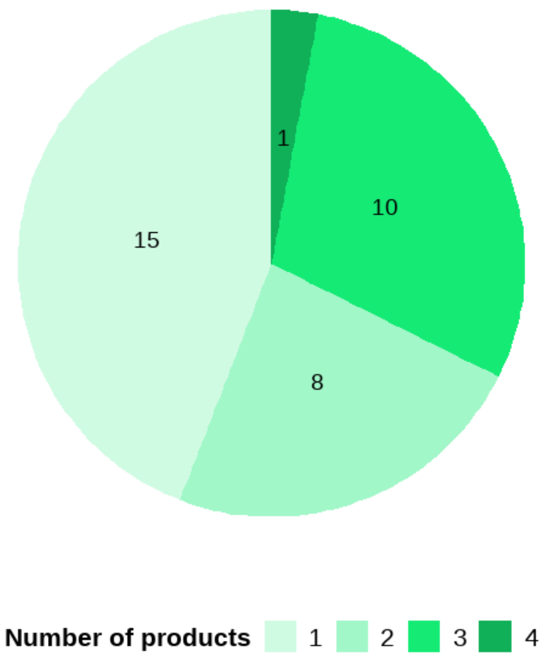


*Figure 2-10: Number of products within the surveyed LFM initiatives (Source: own VITO figure).*

The survey reveals various reasons why LFMs often have multiple products:

- **Purpose:** in some cases, different products are used for different needs and the LFM provides different services. For instance, one initiative has products to resolve problems caused by overproduction due to distributed generators, while other products seek solutions to problems caused by overload (e.g. heat pumps). However, there are also initiatives which define their products in a more generic way in order to cover multiple needs and/or services with one product.

- **Energy versus capacity procurement:** as will be detailed in the sections below, for the same service, some LFM initiatives have defined separate products for (ST) energy and (LT) capacity procurement.

- **Technology-differentiation:** Some initiatives highlighted the need for capacity-limiting products, which can be particularly valuable for certain flexible assets such as EV charging stations. As a result, this type of product was added in several initiatives. For these initiatives, an important consideration was that, depending on the type of flexible assets they represent, FSPs might prefer to bid for capacity limitation, energy, or both. For instance, in some cases, FSPs may be able to ensure that they do not exceed a certain capacity (e.g., by guaranteeing that only two of their three production lines are operating, or by opting for slow charging instead of fast charging). However, they may not be able to commit to reducing their consumption by a specific percentage (e.g. they might be uncertain about whether they will be charging at that moment or whether all production lines will be active).

**Product based on existing product**

Products for LFMs can be based on existing balancing products (e.g. mFRR) or wholesale energy market products (e.g. ID, DA), or they may be distinct. The OneNet project [15] recommends separating products into frequency control and non-frequency control, with frequency products having greater harmonisation potential as they generally do not require locational information. Non-frequency control products have less potential for harmonisation due to their location specificity and the early stage of DSO adoption, which may result in harmonised products that do not fit all DSO needs. OneNet proposed several harmonised products and compared them against demonstrator products. Notably, an mFRR product with a location component received particular attention as it could serve both frequency and congestion management services.

Insights from the surveyed LFMs
The surveyed LFMs and workshop participants largely confirm that product design for local flexibility services prioritises simplicity and responsiveness to local needs over alignment with wholesale or balancing market products. On the other hand, several respondents do see national-level standardisation as a pragmatic step to enable scale, liquidity, and operational integration across system levels and have demonstrated this successfully.

As visualised in the pie chart below (Figure 2-11), only a minority of products used in the surveyed LFM initiatives are based on, adapted from or inspired by existing products from balancing and/or ID/DA wholesale energy markets. In 8 out of the 10 products, products were based on the balancing market. In 2 cases, products were based on ID markets; The latter were cases where the congestion management platform was coupled with ID wholesale markets (e.g. GOPACS, or the ST active energy product in the OneNet Northern Demonstration in Finland which was linked to the Nord Pool ID market). In none of the cases LFM bids were part of the DA wholesale market.

LFMs that make use of and/or are inspired by balancing markets do so because of a variety of reasons.

- **Ability to implement bid forwarding**: In the OneNet Northern Demonstration in Finland or the TDC initiative in Switzerland, they (aim to) test bid forwarding to the balancing market, requiring similar products.

- **Cross-country synergies**: For some products, the platform provider and/or market operator (MO) is active in other markets as well (implying they preserve the link with these markets).

- **Market integration:** One initiative aimed to do as similar as possible to national balancing markets as these markets were more familiar for their current FSPs, allowing them to use the same assets for different purposes (balancing, local services…). Furthermore, it would make it easier in a next step to set up common procurement with the TSO.

In case initiatives indicated that they did not design their products based on the design of existing wholesale market products, they did point out that they based their LFMs products on, or were inspired by, other types of existing products for local services. They looked at products proposed by platform providers, products implemented in other LFM initiatives or previous pilots, they were inspired by research, or their products originated from regulation or national agreements. Finally, there were also SOs that defined new products entirely based on their specific needs, not looking at other initiatives.

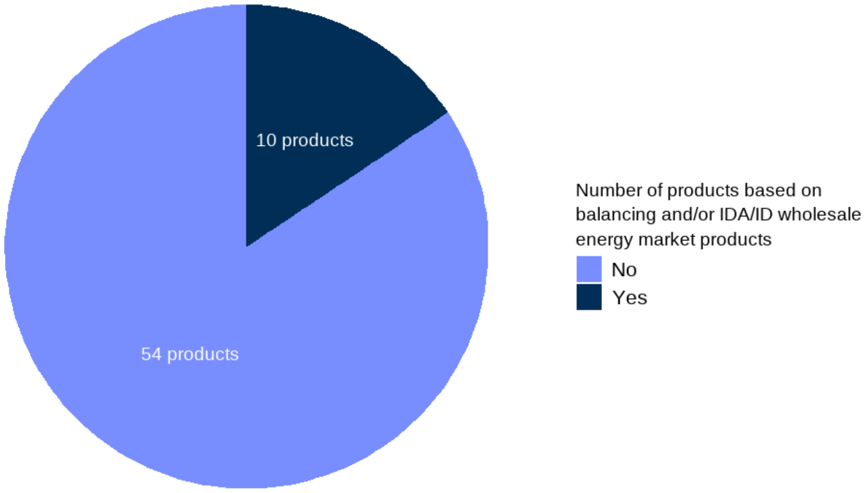


*Figure 2-11: Number of products within the surveyed LFM initiatives based on existing market products (Source: own VITO figure).*

Feedback from the surveyed LFM initiatives and the SO-workshop, highlighted that most (distribution) SOs believe products for local services should be based on local needs (and not on products from existing DA/ID or balancing markets). This is also confirmed by the results of the SO-workshop poll in Figure 2-12, where SOs could indicate on which type of products local services should be based. It was indicated that issues in the distribution grid are often highly localised, requiring specific solutions and thus tailored product specifications in some cases. Furthermore, there is growing concern among DSOs about adopting existing DA, ID, or balancing products for use in LFMs. One key issue highlighted by the surveyed LFMs is that the requirements for balancing products can be more complex, for instance, they require stricter performance and qualification criteria, which raise significant entry barriers, particularly for smaller or less experienced FSPs. Other SOs stress that local congestion management has fundamentally different objectives than balancing - focusing on limiting flows to a certain level rather than correcting frequency deviations - so mirroring balancing designs risks misaligning the product with actual system needs. Ultimately, the concern of the surveyed LFMs is that, in seeking harmonisation, inappropriate or overly complex requirements may be imposed as illustrated above, which could undermine the accessibility and effectiveness of local flexibility mechanisms.

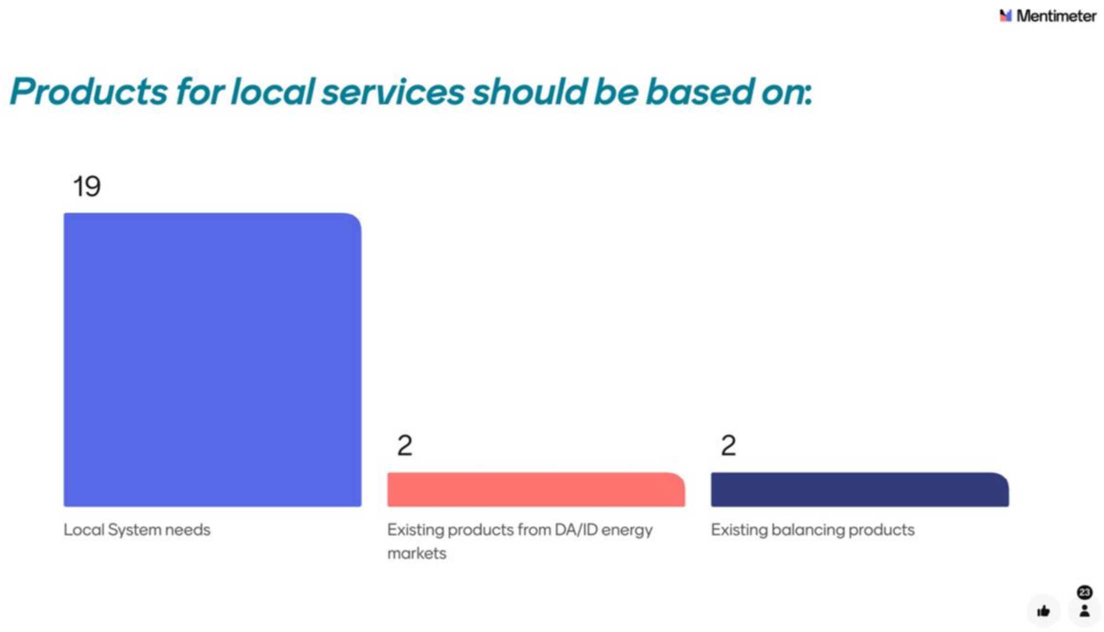


*Figure 2-12: Poll results on definition of products for local services during the SO workshop (Source: SO workshop).*

However, given the fact that quite some initiatives base themselves on existing (non-wholesale market) products (from other projects, countries, or from pilots and research), there seems to be an opportunity to harmonise or standardise these products. Some immature LFMs even welcome this idea as it would give them a proper starting basis. In the SO-workshop, it was generally agreed that, at least at national level, harmonisation would be possible in order to avoid artificial segregation within each Member State. Achieving the same exact product across the whole of Europe was argued to be too complex. During the SO-workshop, a poll was opened, asking whether a mandatory minimum set of attributes for defining local products would be possible. Participants could choose between four options as depicted in Figure 2-13. Most participants indicated that a minimum set of attributes for local products could be defined at national level. This would still allow DSOs to configure their services and products according to local operational needs. The latter was important for a minority who expressed concerns that harmonisation could overlook local nuances and limit DSOs' ability to effectively address local challenges. For instance, the fact that local congestion management is rather focusing on limiting flows to a certain level, instead of correcting frequency deviations. Or, for instance, the fact that liquidity in LFMs is lower, implying that it is more important to ensure multiple FSPs can enter the market. Furthermore, LFMs are still emerging, and some degrees of freedom remain important to boost innovation.

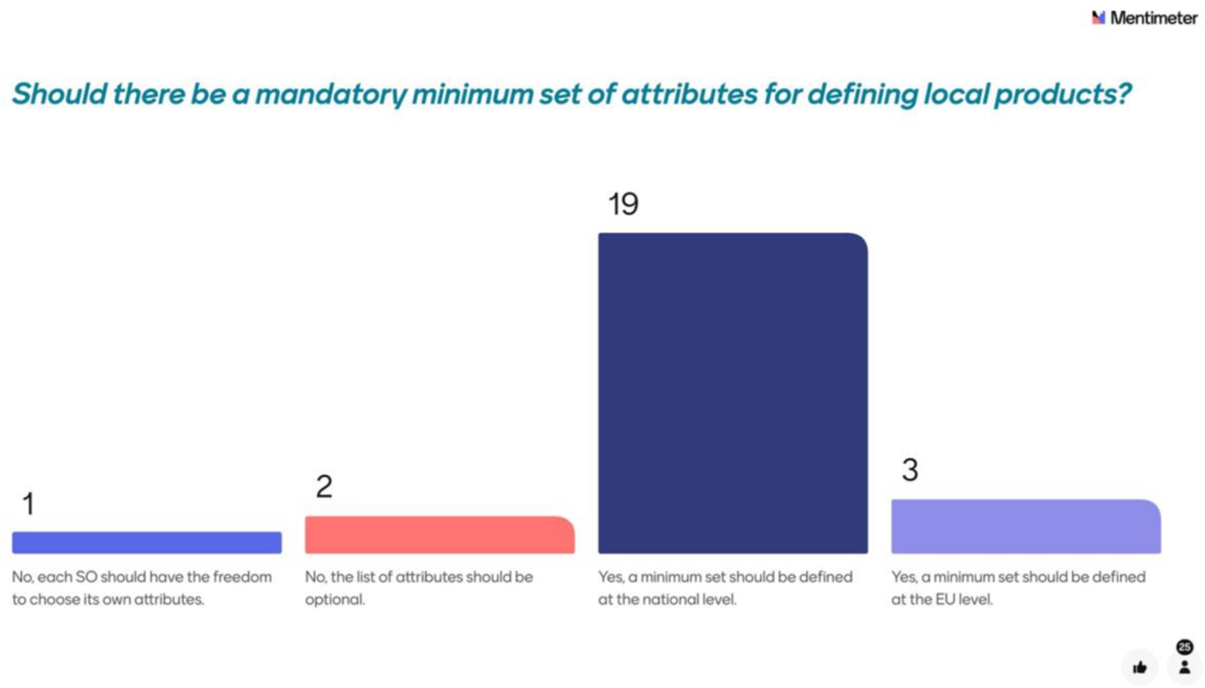


*Figure 2-13: Poll results on product standardisation during the SO workshop (Source: SO workshop).*

As highlighted in section 2.2.1, in some countries, efforts are underway or are taking place to coordinate and harmonise LFM products. The UK has implemented standard products across all LFMs, while Sweden is developing national availability and energy products through a consultative process with stakeholders, the TSO, and NRA. Workshop participants from countries where there was successful product standardisation for local services at the country level, explicitly expressed arguments in favour of standardisation. First of all, given the fact that LFMs are still facing liquidity challenges, it was argued that product standardisation could allow FSPs to operate in multiple markets (TSO, DSO, national), as such **enhancing liquidity and value stacking**. Furthermore, from an IT and system integration standpoint, using standardised or harmonised products **simplifies implementation**, especially when flexibility must be shared between TSOs and DSOs. Some representatives of LFM initiatives emphasise that aligning product characteristics (like activation time or duration) between DSO and TSO services **enhances cooperation** and can avoid conflicts in activations.

**Procurement of active/reactive power**

The next part of the classification framework focuses on whether products entail the procurement of active or reactive power.

<u>Insights from the surveyed LFMs</u>
Most LFMs focus on active power products. The limited use of reactive power products is often attributed to their technical complexity, localised nature, and lower liquidity; however, experience from one mature initiative suggests that, under specific conditions, reactive power markets can offer operational simplicity, clearer value definition, and greater contractual stability, making them a potentially viable complement to active power-based LFMs.

Most products in the surveyed LFMs are active power products. Only 4 initiatives used reactive power products.

Some of the key **arguments highlighted by respondents for not yet using reactive power products** are linked to the fact that markets for reactive power have a high implementation complexity. Procurement of voltage control services with reactive power, requires advanced locational, voltage control mechanisms, making its integration into standard market platforms more complex. Furthermore, commercial platforms were claimed to not have a lot of experience with setting up procurement mechanisms for reactive power. In contrast, active power flexibility can be managed with existing market solutions, forecasting tools and control mechanisms. In addition, it is argued that voltage problems are often even more localized, and they can be managed through passive solutions (e.g., capacitors, transformers). Moreover, active power products generally attract a larger pool of FSPs, including demand response participants, storage operators, and renewable generators. This increases the chances of obtaining a higher market liquidity and FSP participation. Reactive power, on the other hand, can typically be supplied by fewer providers, such as large generators or inverter-based RES (PV and wind turbines) and BESS, etc., limiting market liquidity. It is argued that reactive power is too localized for a market to exist. Another argument to prioritize active power products is linked to regulatory considerations. The market structures and grid codes in various regions prioritise active power procurement. In some cases, reactive power services are not yet fully integrated into market-based solutions and may still be procured via LT contracts or bilateral agreements rather than through competitive market mechanisms. Finally, active power flexibility is more compatible with wholesale electricity markets, including DA, ID, and balancing markets. This allows for better integration and value-stacking opportunities for FSPs compared to reactive power, which is often treated as a service separate from traditional market participation.

However, one of the more established initiatives, the Fluvius market, that both has a congestion management LFM with active power products and a voltage control market with reactive power products, argues that its reactive power market is significantly easier and simpler than its active power market due to its lower operational impact. It was argued that RP is significantly easier to scale and manage as the technical knowhow is already in place, standard baselines (like a fixed cos(φ)) are readily available, and existing telecontrol infrastructure can be leveraged with minimal changes. The service can be defined clearly and contracted over longer periods (e.g., six months), reducing transaction complexity compared to recurring ST market sessions. It should be noted that, in this case, the RP market design was consequently considerably less complex (due to LT contracting) compared to the AP market, which involves multiple products and shorter procurement cycles. Furthermore, the compensation that the DSO is willing to pay for reactive power is much more transparent as the DSO incurs financial penalties from the TSO for the additional offtake and/or injection of reactive power. The compensation is therefore linked to a transparent proxy - avoided penalties for voltage deviations - making the value proposition clearer than in the case of congestion management by means of AP. In addition, for providers, the opportunity cost is low since delivering RP does not require major changes in operations. This results in fewer uncertainties, faster responses to flexibility requests, and higher willingness among participants to engage in longer-term commitments. Unlike AP, which involves more complex baselining and fluctuating market-based pricing, RP allows for stable agreements with FSPs and more certainty in the long-run.

**Energy versus capacity products**

The next categorisation parameter focusses on whether surveyed LFMs make use of capacity products to reserve flexibility with the possibility of activating it during the reserved period; and/or whether they make use of energy products which entail a binding activation and delivery of flexibility. It is also possible that LFMs use a combination of both energy and capacity products.

<u>Insights from the surveyed LFMs</u>

Capacity procurement, often alongside energy products, is a widespread design choice across both mature and emerging LFMs.

From Figure 2-14, it becomes evident that the majority (70%) of the surveyed LFMs (including the sum of the "Capacity and energy products" and "Capacity-only product" bars) do include a capacity product and thus reserve flexibility beforehand. Among this majority, two-thirds combine capacity with energy procurement. Zooming in only on the current operational initiatives (not the finalised ones or those still in preparation), it could be argued that especially more experienced LFMs (the live markets in operation) ensure a mixture of energy and capacity procurement is present in their LFM (6 out of 7). However, as most LFMs seek experience and information from current live markets, even less mature LFMs are choosing for mixed energy and capacity procurement.

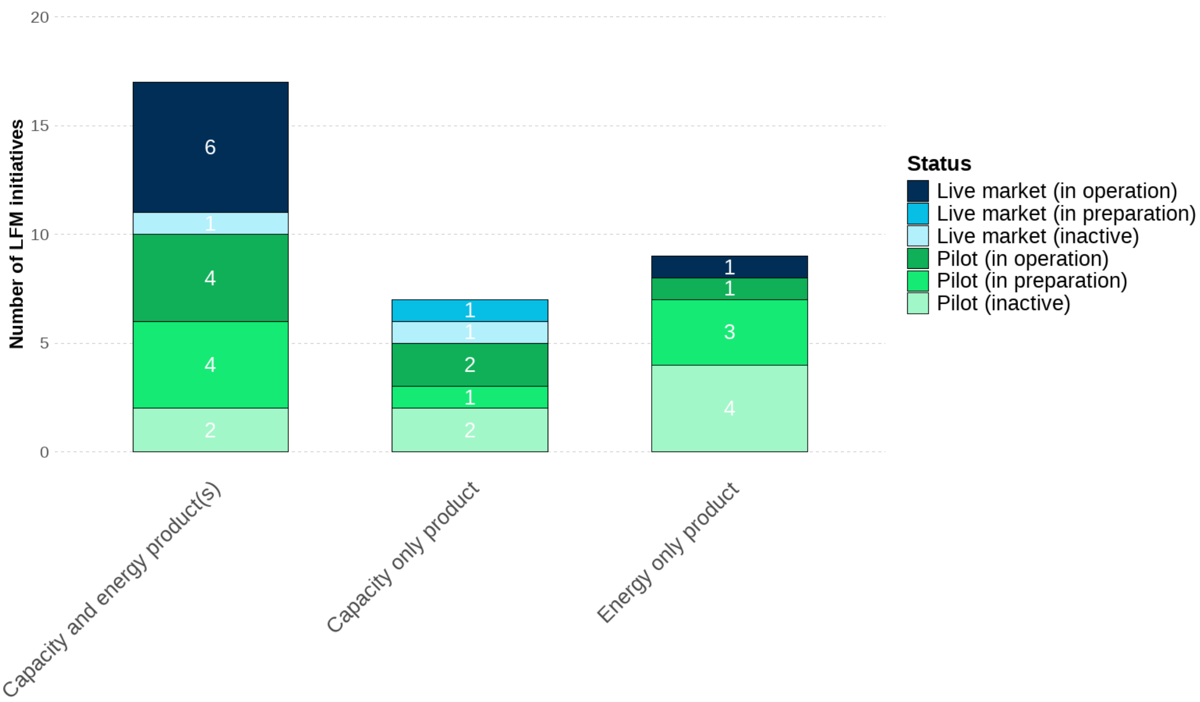


*Figure 2-14: Number of surveyed LFM initiatives with energy products, capacity products or a combination of both (Source: VITO own figure).*

### Renumeration

Linked to whether there is capacity and/or energy procurement, the next categorisation element focusses on the type of remuneration applied in the LFM. It defines how flexibility is remunerated, i.e. whether there is a remuneration for availability (reserved capacity) and/or activation (activated energy).

Insights from the surveyed LFMs
While many LFMs remunerate both capacity and energy, a significant number relies solely on activation-based payments.

From the survey, when looking at the individual flexibility products, it becomes clear that in almost all cases, when there is capacity procurement, FSPs are also remunerated for this. There are, however, examples where when capacity is being procured, FSPs are only remunerated for energy. As depicted in the ID-card of the Fluvius Reactive Power market, this is the case when reserving reactive power over a period of 6 months. FSPs are only remunerated for being activated, as the short activations of reactive power does not affect their business as usual and therefore does not require significant reservation costs for the FSP. FSPs in this case have a very low opportunity cost with no significant operational impacts. Unlike for congestion management, it is for reactive power also easier to set a price as the DSO receives a set-point from the TSO for the next couple of years. Another example is the UKPN LT Scheduled Utilisation product through which FSPs commit to reduce demand or increase generation during pre-contracted windows. FSPs know beforehand when they need to deliver and they deliver the product without having an actual activation signal DA. As such, they are only remunerated for energy delivery and not for reservation as they are expected to deliver in any case during the pre-determined time windows. Finally, there is also the Fluvius active power congestion market in which the MaxUsage product entails capacity reservation linked to an obligation to deliver the service (that is: stay below a certain consumption level in the promised timeframe).

However, on top of capacity remuneration, we see that most products that offer capacity remuneration combine this with energy remuneration. Nevertheless, the number of products only entailing energy remuneration takes up the largest part. It should be noted that although there are 33 products that only involve remuneration for activated energy (see Figure 2-15), a comparison with Figure 2-14 reveals that most initiatives combine these energy products with capacity procurement. Some of the reasons indicated by the LFM initiatives to do so include: a) providing SOs with the flexibility to adapt their needs as they approach the delivery timeframe, when they have updated information on grid status based on forecasts and outcomes from other markets, and b) allowing FSPs the choice to participate in either LT or ST products, depending on their characteristics and capabilities.

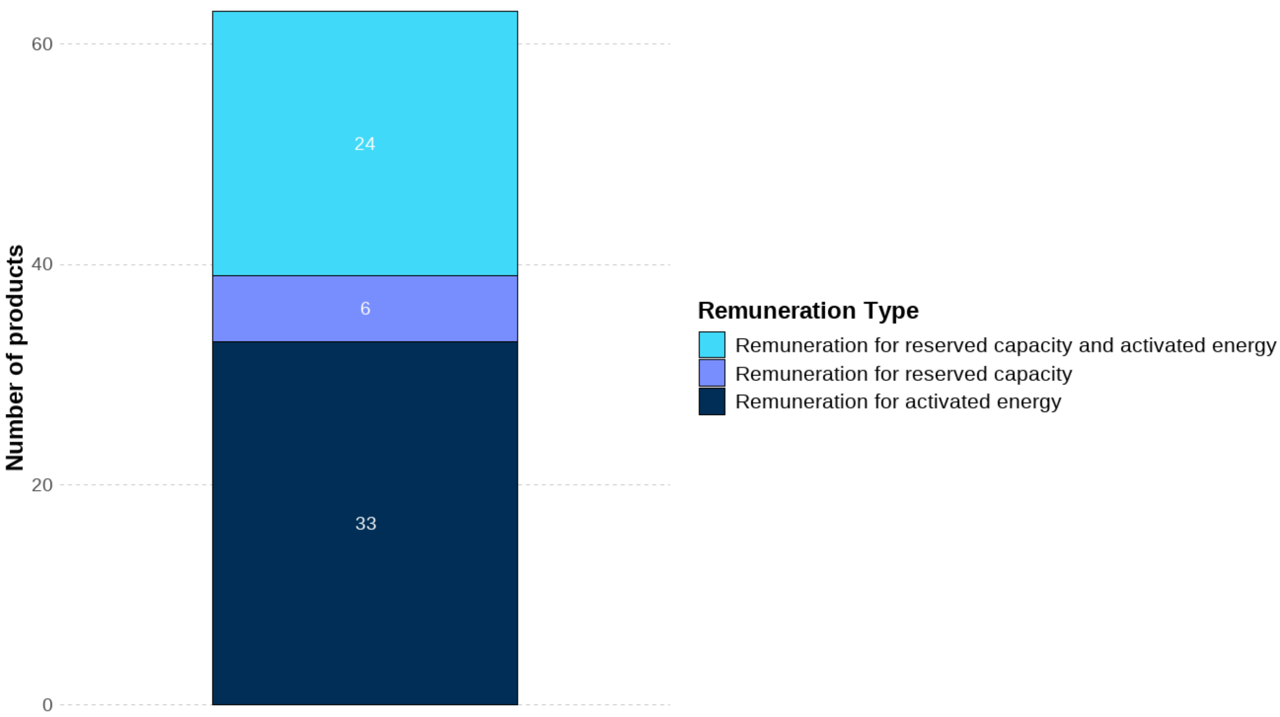


*Figure 2-15: Type of renumeration in the surveyed LFM initiatives (Source: VITO own figure).*

**Aggregation allowed**

An important product design classification feature is whether or not aggregation is allowed, and what level of permitted spatial aggregation and/or portfolio-based bidding is allowed for. Spatial aggregation refers to the process of grouping flexible resources based on their geographical location within the network where the LFM is located. In case of portfolio-based bidding, FSPs submit bids based on an aggregated portfolio of flexible resources rather than individual assets.

Insights from the surveyed LFMs

While aggregation is common in LFMs, its use is limited by technical and locational considerations to preserve grid responsiveness.

As indicated in the figure below (Figure 2-16), most initiatives allow for aggregation in their LFM. However, before aggregation is allowed, in most cases, there are some conditions. Most of the time, only **spatial aggregation** is allowed, meaning that the assets are all required to be located under a specific congested network element and/or within the same network area affected by grid issues. One initiative allows aggregation within defined aggregation zones, which are determined based on grid restrictions and might be highly dynamic. If spatial aggregation is used it should be ensured that all assets have the same effectiveness in resolving the congestion challenge or the individual impact of flexible resources should be properly accounted for. Portfolio-based bidding is generally permitted within predefined spatial boundaries. However, the study indicates that SOs are still developing the necessary expertise, and the practical implementation of portfolio-based bidding in the survey LFM initiatives is currently limited. In some cases, aggregation must be pre-approved by the SO so that he can check if certain conditions related to grid location and impact are met. Measuring this effectiveness is done based on grid operators' knowledge of the grid configurations and safety analysis.

Arguments not to allow for spatial aggregation and portfolio-based bidding differ between the initiatives. Initiatives that apply voltage control indicated for instance that it is highly local, and that aggregation would not provide the same effectiveness as individual, location-specific flexibility. Allowing aggregation could lead to dilution of control effectiveness since voltage issues are not uniformly distributed across the network. Another initiative did not allow for aggregation as they worked with sensitivity factors[3], which they indicated would be too complex in case of portfolio bidding.

[3] Sensitivity factors are calculated to estimate the effect of flexible assets on the DSO needs and thus the usefulness of these assets.

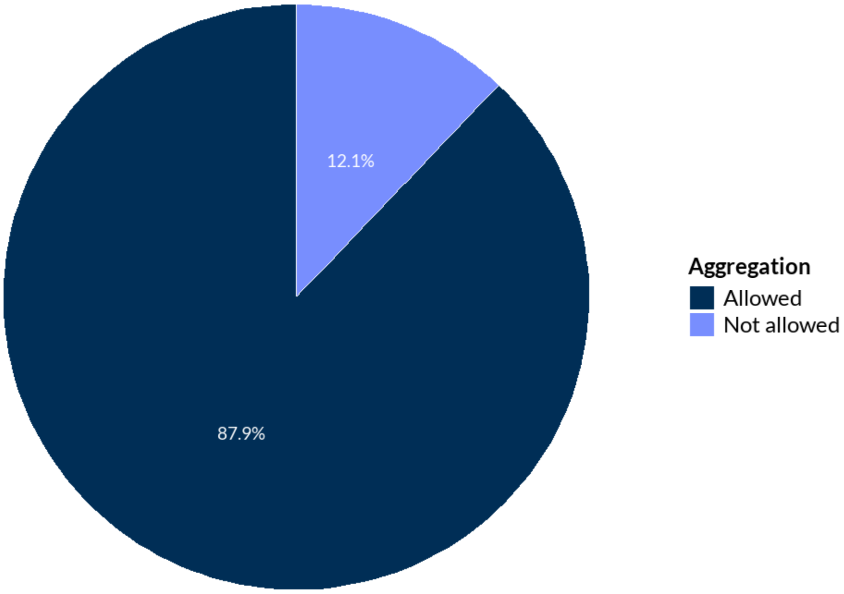


*Figure 2-16: Aggregation allowance in the surveyed LFM initiatives (Source: VITO own figure).*

### Specific product characteristics

Insights from the surveyed LFMs

Beyond the already discussed energy and capacity characteristics, LFM initiatives consider a wide set of additional product attributes, though their inclusion and definition vary significantly across projects. Locational information and delivery period are consistently specified in all surveyed LFMs, while minimum bid size and bid granularity are also commonly defined. Other characteristics - such as full activation time, maximum number of activations, minimum resource size - are included more selectively and with notable differences. In several cases, product design decisions remain undecided or are intentionally left flexible to be adapted through procurement calls. Most initiatives apply simple bid formats and avoid complex bid types, although a minority do experiment with advanced bidding features. This range of approaches reflects the current variability in how LFMs operationalise product design depending on their specific status, system needs, and level of development.

Apart from the already discussed product characteristics, there is a multitude of other product characteristics that could be included in LFMs. The figure below (Figure 2-17) illustrates for some of the potential attributes whether they are implemented in the surveyed LFM initiatives. The analysis of whether certain product attributes are considered across all LFMs reveals significant variations. Locational information and the delivery period are, on the other hand, always defined. Furthermore, in most cases a minimum bid size and bid granularity are specified. In what follows, we discuss these characteristics in more detail, except for the *symmetry requirement* as none of the products of the surveyed LFM initiatives impose symmetry requirements in their products.

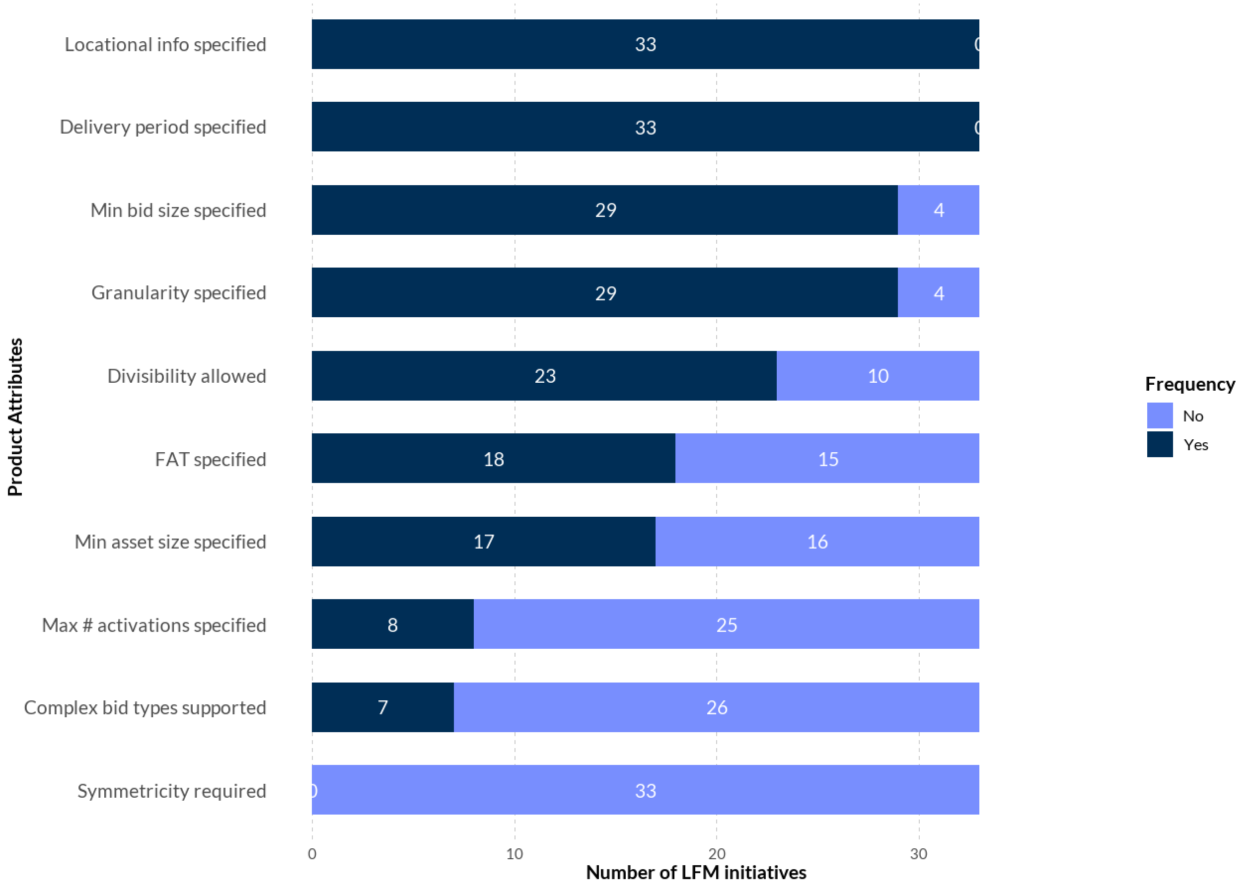


*Figure 2-17: Product attributes considered by the surveyed LFM initiatives (Source: VITO own figure).*

*Locational information*

As all local services are by definition required for specific locations, it is indispensable that FSPs indicate where they can offer flexibility. This can be done by specifying per bid a locational tag, indicating how the flexibility resources can be connected to a specific grid location. In the majority of the surveyed LFM initiatives the location is however checked during the PQ phase, making sure the flexible assets are located in the affected grid areas through the location of their connection. Within the surveyed LFMs, different approaches were found. Some initiatives require locational tags at the level of the connection of flexible resources, while others use tags at specific grid-elements (e.g. grid nodes or feeder level). In other cases, substations or specific zones are defined and the flexible assets need to be located therein. Alternatively, locations are defined through postal codes which may lead to suboptimal results, since postal codes typically do not correspond precisely to network boundaries.

*Duration of delivery period*

Most surveyed LFM initiatives choose for a fixed delivery duration period, generally, between 15-60 minutes. There are also some initiatives that define a minimum delivery period. Generally, minimum delivery periods start around 15 minutes. Furthermore, there are also initiatives that define a maximum delivery duration period (for instance 4 hours), or initiatives that define both a minimum and a maximum delivery period (for instance between 1-12 hours). However, the exact delivery period depends on the final needs of the SO which can, in the case of congestion management, be multiple consecutive hours. Finally, there are also LFMs which are still deciding upon their delivery duration period.

The duration of the delivery period can be found in the different ID-cards of the LFM initiatives in Annex 2.

*Minimum bid size*

The majority of surveyed LFMs define a minimum bid size, while only few do not. For instance, in Lithuania, there is currently no active LFM as there is no concrete flexibility need, but the regulatory framework has been set up. Only when real flexibility needs occur, and the market would be opened, minimum bid size could be further defined in procurement calls and as such be adapted towards specific needs. Those who define the bid size often have a small minimum bid size (e.g. 1 kW) or medium sized minimum bid size (e.g. 10-100 kW). In some cases, they have comparatively high minimum bid sizes (0,5-1 MW).

*Granularity*

Most initiatives define granularity. Quite often, rather small granularity levels are chosen (ranging from 0.3 to 1 kW), but some are also specifying more medium granularity levels above 20 kW. Few of the surveyed LFMs focus on higher granularity levels (e.g. even up to 500 kW). There are examples of initiatives that also vary their granularity levels depending on the voltage level to which the participating resources are connected (for instance a 100 kW granularity requirement for MV-connected resources, while this is only 1 kW at LV), or depending on the product/service procured.

*Divisibility*

Most initiatives support divisibility only in terms of quantity, but not (yet) in time. Conversely, there are also initiatives that allow divisibility only in time - enabling SO or MO to select specific portions of the time window during which flexibility is procured. In some cases, initiatives leave the decision of whether a bid is divisible to the FSP, allowing FSPs to specify, for each offer, whether it can be partially accepted. Finally, some initiatives rely on indivisible bids, as this approach is simpler to implement. However, even among these, some keep the option open to introduce divisibility in the future. When divisibility is not permitted or defined, the FSP must comply with the SO's request, and the SO / MO is required to activate the full bid amount.

*Full activation time*

For more than half initiatives, full activation time is not explicitly defined. Instead, it is a consequence of the timing of the activation signal. Furthermore, SOs sometimes explicitly mention that it is up to the FSP to take into account ramp up / ramp down periods as this might have a negative impact on their compensation. When activation times are being defined, they range from very fast response times (under 10 minutes) for cases where immediate congestion relief is required, to more moderate (10-30 minutes) and even longer activation windows (over 30 minutes and up to multiple hours). Finally, there are also initiatives that are still in pilot phase and indicated they will verify during the tests whether it is necessary to define this product characteristic.

*Minimum resource size*

Abou half of the initiatives do not define this product characteristic. However, quite some initiatives do define it, with values ranging from 1 kW to 500 kW. Arguments to have such asset limits in place are for instance linked to technical minima of allowed assets (e.g. targeted water heaters). However, more frequently used arguments are linked to the fact that lower (bid and) asset sizes make it mathematically too complex to run and optimise the LFM as the combinatorial effect of small bids is quite large. Nevertheless, it should be noted that these concerns should be resolved by aggregation which should have a positive impact on the optimisation problem the LFM is to solve. Finally, it was also argued that a minimum asset size was also desired to guarantee DSO observability in some cases.

*Maximum number of activations*

From the survey results, we generally see that most initiatives do not explicitly define this product characteristic. This implies that most initiatives operate without a predefined number of activations. Generally, it is stated that FSPs determine the maximum number of activations indirectly through the number of bids they place. Alternatively, it is also possible that the FSP is allowed to define a maximum and minimum for consecutive activations, and resting periods between activations. Initiatives that do define a maximum number of activations, for instance say that an FSP can only be activated once in a given time period or impose strict limitations such as one activation per 2 days, 2 activations a day, or maximally twice a week.

*Complex bid types*

Generally, the surveyed LFMs apply simple bid formats where FSPs need to indicate limited information. Standard bid formats contain price and quantity information, together with the location and the timing. Many LFMs are still experimenting with their first market design, and they aim to keep it simple, allowing where possible for freedom in the bid format. In the future, they might change their bid format. One fourth of the initiatives do use some more advanced bid types. These initiatives, for instance, allow FSPs to configure their minimum and maximum quantity for multiple consecutive hours, allowing as such for some smartness in the bidding as FSPs can play with their profiles. Furthermore, FSPs can place block restrictions on its bids, as such specifying conditions under which their bids may be bought (e.g. minimum number of delivery blocks, maximum number of delivery blocks, minimum contiguous delivery blocks, maximum contiguous delivery blocks and the resting time after activation, hours available…). Another example is the use of a block product covering multiple Market Time Units (MTUs) with conditional activation, which allows FSPs to indicate, for instance, that they are available for a 4-hour period but can only be activated for, say, one hour within that block. This is for instance relevant for products with seasonal availability.

### *2.2.3 Market design*

This section introduces the market design characteristics that are part of the classification structure, according to the different market phases that can be distinguished, i.e., PQ, procurement, activation, and settlement. In addition, we will also discuss aspects related to strategic behaviour and gaming in the context of LFMs.

#### 2.2.3.1 Prequalification

PQ is the process used to assess whether an FSP meets the necessary requirements before being able to participate in a LFM. Several forms of PQ are distinguished and discussed in the following sections: **service provider PQ**, **product qualification** and **grid PQ** as can be seen in Figure 2-18. In addition, an overview is provided of the use of **flexibility registers** in the different LFMs. A **flexibility register**, sometimes also called flexibility resource register, or Flex register), contains structural information on connection points that can provide flexibility services to SOs [123]. It can be considered a supporting tool to implement PQ processes as well as processes for baselining, verification, and settlement. The objective of the register is to gather and eventually share relevant information on (potential) sources of flexibility.

Generally, independent of the type of PQ, it should be noted that, especially for the pilot projects, or markets in preparation, PQ rules are often still under development. In those cases, there might be no formal PQ yet. Especially, when only a limited number of FSPs are involved or the LFM initiative focuses on testing the technical operation of the LFM, there is no urgent need. Nevertheless, it should be pointed out that even in operational markets, there is a general trend of keeping PQ requirements and processes for LFMs rather simple.

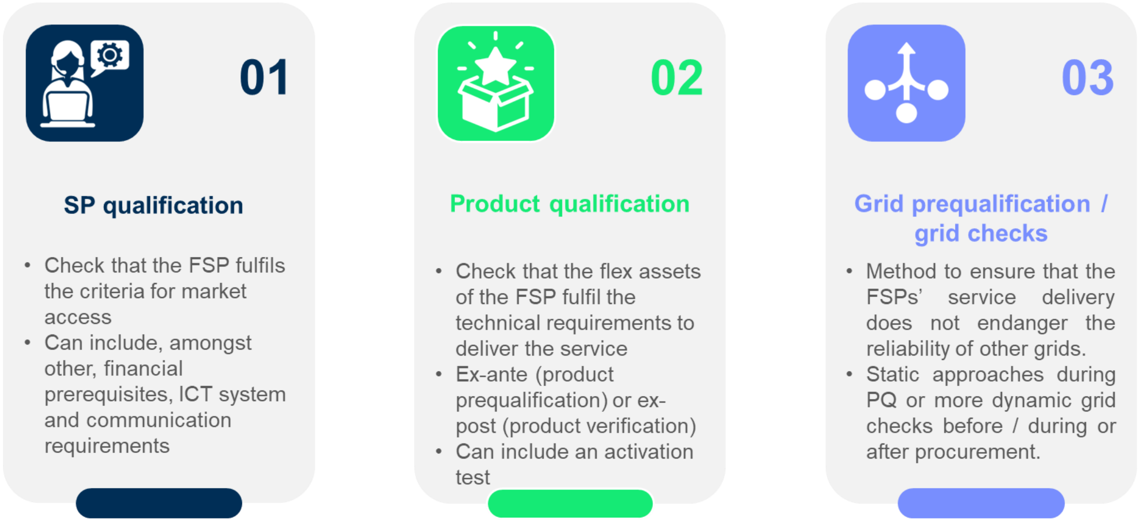


*Figure 2-18: Types of qualification applicable in the context of LFM (Source: VITO own figure).*

### Service provider prequalification

PQ is the process used to assess whether an FSP meets the necessary requirements before being able to participate in a LFM. A distinction is typically made between, i.e., the **Service Provider PQ** and the **product qualification** (see next section). The Service Provider PQ first checks whether the potential FSP fulfils the necessary criteria for market access, including communication and ICT requirements, for market participation and service delivery.

Insights from the surveyed LFMs
Most LFMs apply basic legal, administrative, and commercial eligibility checks during FSP PQ to ensure reliability and accountability, while financial checks are rare; approaches vary from manual processes to standardised platform-based onboarding, with some initiatives combining FSP and product qualification into a single onboarding phase.

Generally, we see that most initiatives apply a minimum number of legal, administrative, and/or commercial eligibility checks as part of the service provider PQ process. This typically includes verifying that entities are properly registered businesses, capable of operating in the respective country, and meet general reliability standards. It should be noted that there are less mentions of financial checks as this is deemed less relevant for LFMs that are still in an early stage of development. Those initiatives that do require financial guarantees usually have more close linkages with other markets where this is more standard.

Some initiatives rely on national platforms or procurement portals to manage these checks, others use dedicated modules for registration and PQ or rely on the PQ systems provided by their commercial flexibility market platforms, using standardised onboarding procedures where applicable. In several cases, this process is still taken up manually by the DSO and is then often separate from the flexibility platform. For some LFM initiatives, there is also a need for signing market membership agreements. The registration is often completed via a flexibility register (see also following sections). Furthermore, some initiatives refer to this phase rather as an FSP registration phase, where the FSP needs to be acknowledged as a formal market participant. The general aim is to ensure a basic level of trustworthiness and accountability from the participating FSPs. It should be noted that in some markets today, only a minimum number of administrative checks is done, only focussing on some of the elements indicated above (for instance only administrative checks, and no formal or financial checks). Finally, some initiatives, explicitly point out that in the registration or SP PQ phase, it is key to ensure an FSP understands the process he enrols in (e.g. bids are binding, product specifications are in product sheets, etc.).

**Product qualification**

Product qualification ensures compliance with the technical product delivery requirements. Related to the latter, the FGDR [9] introduced **Product Verification** as an alternative to Product PQ. In the case of Product PQ, compliance with the technical product requirements is assessed beforehand (ex-ante), while Product Verification evaluates service delivery, and thus the compliance with the technical requirements, after the fact (ex-post). The (latest draft of the) network code on demand response (NC DR) [10] has also suggested the use of product verification as a default qualification option for a number of services, such as congestion management and voltage control, in addition to specific balancing services.

Insights from the surveyed LFMs
Among the surveyed LFMs, there is a trend to keep product qualification rules and requirements for LFMs rather simple. Qualification rules are often still under development, or no formal qualification is in place, giving responsibility to the FSP to ensure they can deliver the product.

For product qualification, typically, product characteristics are predefined and published in product sheets, which flexibility providers must agree to before offering their services. This ensures the technical feasibility and compatibility of the offered flexibility with the operational needs of the grid. It implies that for many LFMs, it is the responsibility of the FSP to ensure he qualifies as he agrees beforehand with the product characteristics. When participating (bidding) in a market procedure, the FSP implicitly agrees to the applicable product fiche. Quite some initiatives pointed out that FSPs are only paid based on delivery, meaning that no further checks are needed from the DSO side. Product PQ is therefore done indirectly through the market rules.

Some initiatives carry out basic tests or checks, for instance regarding the required minimum bid size, the correct voltage level, the direction of flexibility delivery, the location of the assets... However, they consider this rather as verifications, not really as product qualification. Prequalification tests are therefore often not required. This can be explained by the fact that flexibility connected at lower voltage levels typically consists of numerous small assets, unlike the larger FSPs directly connected to the transmission grid. As a result, individually testing each asset would be cost-prohibitive. Hence, for PQ, registration by FSPs is often deemed sufficient at this stage.

Nevertheless, there are also initiatives that also include more explicit ex-ante validation processes to ensure that flexibility products meet technical, locational, and operational requirements. Where possible, this is done in a rather automated manner, for instance based on resource group characteristics and product requirements, as such, limiting the number of efforts required. Further common approaches include technical tests such as communication readiness, as well as checks ensuring baselines can be transmitted properly. A limited number of initiatives indicate that they are aligning with existing PQ processes (e.g. for balancing services), implying that if an asset is prequalified for such services, it is also - at least partially - considered prequalified for the local service. Finally, only a few initiatives perform 'test trades' or 'activation tests' for the product with which the FSP plans to participate in the market. A minority of the initiatives does product qualification based on ex-post measurements.

**Grid prequalification**

As part of PQ, a process can also be put in place to ensure that the delivery of SO services does not compromise the safety of the grids, which is often referred to as **grid PQ**[4]. Grid PQ is aimed at ensuring that the activation of flexibility resources does not compromise the operation of the grid where the resources are located or any other connected or impacted grids. It should be noted that grid PQ can be conducted at different stages, either as part of the PQ process (i.e., before or alongside product PQ), which is often referred to as **static grid PQ**, or more **dynamically**, closer to the actual procurement of flexibility. In the latter case, a distinction can be made between the following three approaches, which occur before, during, or after the actual procurement, as also explained in [20] and explained in more detail in BOX 1: 1) Dynamic grid PQ, 2) Integration of grid constraints in market clearing and 3) Ex-post validation

*BOX 1: Dynamic grid PQ*

**Dynamic grid PQ:** The impacted SO assesses potential grid issues closer to the actual flexibility procurement (e.g., day-ahead or intraday) and determines where flexibility activation should be restricted with the aim to take into account the dynamically changing state of the grid. Solving an optimal power flow problem is completely separated from the market clearing. This allows SOs to keep their sensitive network data private and reduces information flows between SOs and the MO.

Multiple methodologies to perform dynamic grid PQ have been developed in the literature. For instance, [21] proposes a grid PQ method where the distributed resources that can create line congestion are identified through a power flow analysis of all the distribution lines, and the maximum bid quantities of the bids are adjusted based on their contribution to the potential congestion in all lines. The same set of authors proposes a two-stage PQ algorithm based on iteratively solving OPF (Optimal Power Flow) problems in [22]. In [23], an optimisation-based iterative PQ method is proposed, where bids are discarded one by one, starting from the most expensive one, until the remaining bids are safe to be fully activated. In these papers, a linear model is used to represent the network and its constraints.

Differently, the authors of [24] and [25] use the operating envelope approach [26] as a dynamic grid PQ method. Specifically, optimal power flow problems are solved to calculate grid-safe limits (OE limits) of all flexibility resources. In [24], different power flow models used in the OE-based PQ method are compared. These works highlight the need of the use of a suitable network representation and calculation method when computing OEs. Another grid PQ method that has been proposed in a pilot project, e.g. [27], is by using the traffic light system, which indicates the congestion level of a distribution network (which can be classified into three phases, red, amber, and green, with predefined thresholds for each colour). As a PQ method, the worst-case network state for each direction (upward and downward) when the bids are activated is determined by the system. Then, the responsible SO can obtain a recommendation for bid selection, based on the indication given by the traffic light system. Key commonalities among these different grid PQ methods are the use of a network representation and the need to compute

[4] We note here that we take a broader definition for grid PQ as compared to the NC DR, where in the latter a differentiation is made between grid PQ (taking place, typically, in parallel with product PQ) and short-term procedures to account for temporary limits.

the states of the network (i.e., voltage magnitudes/angles and/or real/reactive power flows).

**Integration of grid constraints in market clearing**: The market-clearing process incorporates potential grid constraints to ensure that procurement decisions align with grid limitations of the impacted grids, as discussed in [28], [29], [30]. This process integrates the most recent state of the grid in the market clearing constraints. Consequently, the associated SOs must be willing to share their network data with the MO or a set of constraints (e.g., OEs) that the market clearing should respect. Furthermore, the computational complexity of the market-clearing problem can increase since the formulation of grid constraints highly depends on the network model used, and the latter can be nonlinear, especially concerning distribution systems [31]. However, other less-dynamic forms have also been used, to reduce the need by the SO for frequent grid model calculations and communications of results, e.g., as reported in [32].

**Ex-post validation:** Once market clearing is completed, a final validation is performed to check whether the market outcome could cause grid issues [16], [27], [33]. If necessary, adjustments are made [16], [23]. While [27] uses the traffic light system, i.e., assessing the network status based on the set of cleared flexibility bids to provide recommendation on which cleared bids can be activated, the works in [16], [23], [33] discuss a market-based adjustment of the remaining flexibility bids without modifying any bids that have been cleared, i.e., an additional market is run to commit additional flexibility resources. However, alternatives in which pre-set rules are used for ex-post validation are also possible.

Insights from the surveyed LFMs
Generally, there is only limited consideration of the impact of flexibility procurement through LFM on other grids.

In 60% of the surveyed LFMs, there is no consideration of the impact of flexibility activation on other grids. When applied, grid PQ is conducted for assets connected to the distribution grid, intending to participate in TSO markets. There is quite a wide variety in approaches in the surveyed LFMs.  In about 20%, consideration of impacted grids is part of the PQ phase; In the other 20% of the cases, a more dynamic form of grid PQ is applied or impacted grids are considered in the procurement phase. There are initiatives in which the DSO can block bids from TSO markets if they detect potential congestion or voltage problems. Other approaches include the usage of a sort of (rather static) network feasibility study or a sort of check of the maximum injection and withdrawal of the connected resources and its related impact. The later analysis is re-evaluated only in case there are updates to the connection agreement. This can be done through general studies, but in some cases implies the performance of specific tests before awarding contracts. Furthermore, a couple of surveyed initiatives have a traffic light system in place. There are examples in which case this TLS is working continuously, implying for instance that the TSO checks it every day before the market opens; Nevertheless, there are also initiatives that do use more dynamic aggregates to avoid grid impact. Finally, in a rare case (e.g. Finnish OneNet demo), grid limitations of both TSO and DSO are integrated in the clearing phase.

Those initiatives that do not have grid PQ, have not thought about it yet, or they state that the current size of the market is too small to have an impact. Some initiatives that do have grid PQ in place, also argue that they do not experience actual (negative) impacts yet. Other initiatives state that they currently do not consider grid PQ, but that they are coordinating with the TSO to develop solutions, for instance by applying dynamic limits.

### Simplified prequalification

Several of the LFM initiatives have adopted various approaches to simplify PQ in order to lower barriers for participation and promote inclusivity, especially for smaller FSPs. It was stated that, especially for smaller consumers, the remuneration of end consumers does not outweigh the financial and behavioural investment in providing flexibility. The LFM design should therefore ensure that they can participate with few efforts. It is important to keep in mind that in LFMs, there is a higher likelihood of having many small transactions instead of few large ones. To facilitate this, most initiatives apply a minimal process that only involves for instance registering and verifying the connection power of the participating assets. The focus of the LFMs is on uniformity across all resources, with many initiatives enabling PQ at an aggregated level - allowing portfolios or groupings of assets to qualify together. This is often supported by the use of flexibility registers (see following section), which streamline the grouping and management of technical units. In cases where FSPs already prequalify for balancing or other system services, some LFMs waive additional requirements in the sense that the FSP/asset is directly prequalified for the DSO as well, thereby aligning more closely with TSO procedures. Several initiatives have indicated that their PQ processes are already highly simplified and do not necessitate further adjustments. Additionally, the use of IT tools and solutions such as APIs (Application Programming Interfaces) plays a vital role in facilitating efficient processes, including bulk uploads.

### Flexibility register

As part of the classification process, aside from describing the PQ process, it has been verified whether the initiatives use a dedicated or shared Flexibility Register to record and manage information about FSPs and their flexibility resources.

<u>Insights from the surveyed LFMs</u>
80% of the LFMs use a flexibility register to track and manage flexible assets. In most cases, this register is established at the LFM level, but a significant number also share information with at least one other market.

Flexibility registers play a significant role in an LFM, serving as central tools for tracking and managing flexibility assets. As visualised in Figure 2-19 most platforms feature some form of flexibility register (only 8 initiatives do not (yet) have a flexibility register). However, the scope and accessibility of flexibility registers vary. Typically, these registers are accessible only within the respective LFM, although 7 initiatives aim to extend access to other markets or even establish national flexibility registers - sometimes coordinated by regulatory bodies. For instance, common flexibility registers are put in place in GOPACS, RomeFlex and the Spanish Regulatory Sandbox, but also the OneNet Northern demo in Finland and the Czech Republic demo. However, national registers do not automatically grant SOs access to all resources; visibility can for instance be limited to assets connected to each individual SO's grid. Some advanced initiatives have developed shared registers that integrate both DSO and TSO functionalities, especially for congestion management, as balancing resources may still be handled separately by the TSO through other internal systems (e.g. in the Netherlands). Innovative features, such as traffic light systems that reflect asset availability are in some initiatives also already integrated in the flexibility register. Best practices in flexibility register design include functionalities for comprehensive resource data management, such as asset registration, grid location linking, meter data integration, portfolio association, and the ability for SOs to validate and approve asset statuses. However, access rights for FSPs differ across initiatives: in some cases, FSPs can register and manage their assets directly, while in others they lack editing or monitoring permissions. Despite these disparities, several LFMs that currently lack such registers have expressed intentions to implement them in the near future, recognising their value for transparent and efficient market operation. It is worth noting that flexibility registers can carry functionalities beyond those limited to PQ. Indeed, in addition to having a register for flexibility resources, flexibility registers can play a key role for baselining (for the computation of appropriate baselines), verification (as a central registry for activated flexibility in each market time unit supporting a streamlined automatic verification process), and settlement (providing the inputs data for settlement as well as any compensation schemes for independent aggregation or penalty mechanisms for non-delivery), as well as in the ex-post calculation of available flexibility in the system.

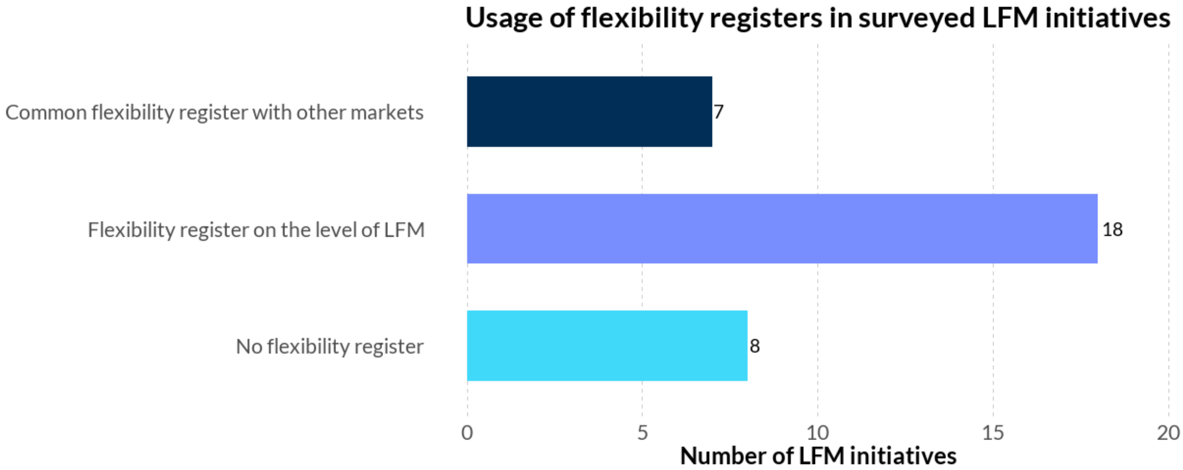


*Figure 2-19: Usage of flexibility registers in surveyed LFM initiatives (Source: VITO own figure).*

### 2.2.3.2 <u>Procurement</u>

During the procurement phase, flexibility requests and offers are collected, and the market is cleared (implying that requests and offers are matched, determining price and quantity of flexibility to be delivered by each FSP). As part of the classification structure, the aim is to build a representative view on the key aspects of procurement in LFM, such as the market timings, market objective, the clearing mechanism, the approach towards final bid selection, the network representation in the market and the pricing arrangements.

**Market timings**

Related to the market timings of an LFM, the goal is to identify the different timeframes and deadlines that govern the procurement processes, in particular when the LFM opens (e.g., gate opening times, or tender opening timings) and closes (e.g., gate closure time for auction-based markets, conclusion time(s) of continuous trading for continuous markets), the market clearing timing, and the timing of publication of the market outcomes. These timings define when FSPs can interact with the LFM and place the LFM within the time context of other electricity or services markets, enabling the assessment of their time coordination and implications thereof on the FSPs' participation potential, anticipated market liquidity, and market efficiency. A distinction is made, where relevant, between the market timings for capacity procurement (reservation of flexibility), energy procurement, and this with respect to timing of the activation of flexibility.

<u>Insights from the surveyed LFMs</u>
The different LFM initiatives surveyed, use varying timings for capacity procurement (if applicable), energy procurement, and activation requests. Capacity procurement in LFMs is in general done longer before delivery compared to standard balancing capacity products. Energy procurement in LFMs is mostly done in the DA and/or ID timeframe.

As indicated previously, the majority of the surveyed LFMs includes reservation of capacity. The different LFM initiatives surveyed, use varying timings for capacity procurement (if applicable), energy procurement, and activation requests, where these are issued. Figure 2-20 shows these timings for all the products of the different surveyed LFM initiatives in relation to the timing of flexibility delivery. More LT timings (year ahead to week ahead) are given blue shadings. More ST timings (DA and ID) are given green shadings. Real-time timings (hours to minutes ahead) are given a light green colour. Furthermore, grey colours are used when the certain timing does not apply (i.e. there is no capacity and/or energy procurement or explicit activation), or when these timings still need to be decided upon (dark grey). To ensure consistency in interpreting this figure with Figure 2-14, note that when it comes to capacity procurement Figure 2-20 shows that many initiatives, even though implementing capacity procurement, have not yet decided on the timing of when this capacity procurement is about to take place. Furthermore, Figure 2-20 shows the total number of products while Figure 2-14 counts the initiatives.

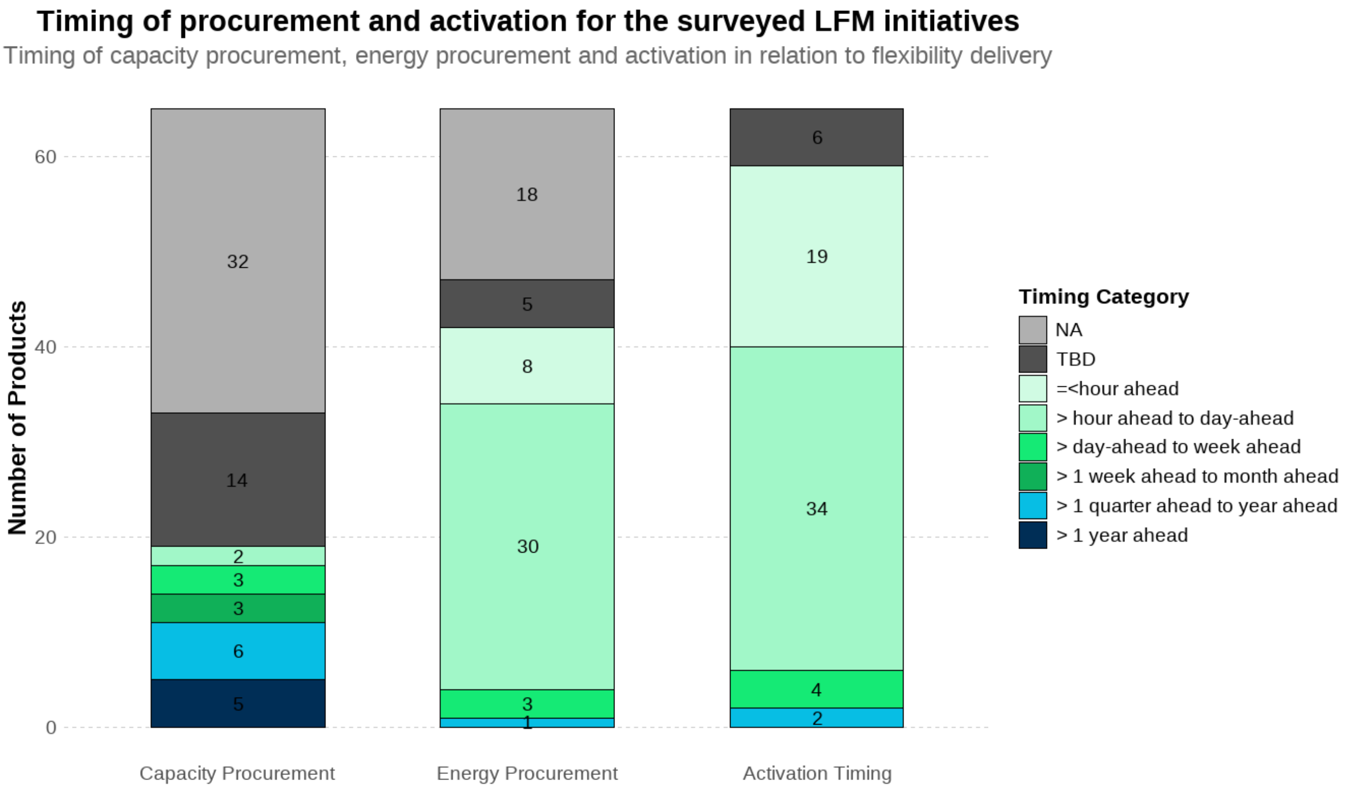


*Figure 2-20: Timing of capacity and energy procurement and flexibility activation in relation to the flexibility delivery for the surveyed LFM initiatives (Source: VITO own figure).*

The following observations can be made from the figure:

- It is obvious that generally, **capacity procurement** in LFM is done earlier ahead of delivery compared to standard balancing capacity products. In some cases, it is done months or years ahead of delivery. While in other cases, it is done week or day ahead. There are also products where the capacity procurement timing is not fixed, and the DSO maintains the option to adjust the timing depending on its needs. This allows the SO to procure flexibility considering updated flexibility needs or unforeseen circumstances.

- **Energy procurement** is generally carried out either in the DA or ID timeframe. Some of the surveyed LFM initiatives apply fixed timings for energy procurement, while in other cases, the procuring SO can decide ad hoc whether and when energy procurement is needed. The latter approach is sometimes used when capacity procurement is conducted LT ahead of the delivery timeframe and/or when the SO believes this could enhance liquidity and promote greater price competition. Some initiatives do not include explicit energy procurement. Additionally, it should be noted that energy procurement is sometimes directly linked to earlier capacity procurement. For example, when an FSP is accepted during the capacity procurement phase, this may entail an obligation to participate in the energy procurement phase.

- In most cases, the market outcome entails a need to activate during the delivery time slot, while for some LFM initiatives an explicit, separate **activation signal** is sent. About half of the respondents indicate that activation is done **DA to hour ahead.** Nevertheless, there is also a significant number of products that are activated close to real time. This includes some cases of direct DSO control as discussed in section 2.2.3.3. Some initiatives have indicated that, as forecasting improves, they aim to activate congestion management services 24 hours in advance. In theory, activating closer to real-time would lead to more accurate grid need predictions, ensuring that only the necessary capacity is activated. This could reduce overall activations, as earlier activations tend to include a risk margin. However, for the market to function effectively, it may be preferable for the majority of activations to occur earlier.

**Market objective**

LFMs can have different market objectives to be met by the market mathematical formulation and clearing algorithm, such as the maximisation of social-economic welfare, or the minimisation of flexibility procurement costs, among others.

All surveyed LFM initiatives pursued purely economic objectives, primarily aiming to minimise flexibility procurement costs. This objective extends to both capacity and energy procurement phases.

**Clearing mechanism**

In addition, different clearing mechanisms can be used to match bids and offers for the market-based procurement of flexibility. LT as well as ST procurement is in scope. We distinguish here between **closed-gate auctions**, **continuous trading**, **tenders**, and **bilateral trades**.

- Closed Gate Auction (CGA): Fixed submission deadline ("closed gate") and bids are evaluated and matched in a single clearing process.

- Continuous market: Bids and offers are matched continuously as they are submitted. There is typically a time window in which bids are accepted.

- Tender: SOs invite FSPs to submit bids to supply local services over a defined period. This type of mechanisms mostly entails reservation of flexibility for a longer duration (LT contracts).

- Bilateral trade: Direct agreement between the buyer (SO) and the seller (FSP) to deliver flexibility with direct negotiation between them.

Insights from the surveyed LFMs
Closed gate auctions are the dominant trading mechanism across surveyed LFMs, while tenders and continuous markets are less commonly used and equally represented; tenders are primarily applied for LT flexibility reservation, whereas continuous markets are often used for intraday trading or mimic a CGA by trading within defined time windows. Bilateral trading is limited to a single initiative and in this case, it is specifically used for capacity-limiting contracts and flexible connection agreements.

Figure 2-21 visualises the different types of market-clearing mechanisms that are implemented in the different LFM initiatives. Closed gate auctions are used most frequently, while continuous markets and tenders are also used in a significant number of cases. The following observations can be made from the survey:

- **Tenders** are typically used in case capacity is being procured over a defined and longer period of time. However, in our study, we encountered one LFM initiative (the French Enedis LFM) that took a slightly different approach: instead of reserving capacity, the LFM contracted multiple FSPs in advance. These FSPs were not required to commit to constant availability but allowed the DSO to contact them with activation requests. The FSPs could then still indicate whether they were capable of providing flexibility or not. When looking at the surveyed LFM initiatives, we observe two distinct approaches to tenders: most follow a fixed, recurring schedule (e.g., an annual procurement cycle), while others open tenders on an as-needed basis (e.g. ad hoc constraint based).

- **Continuous markets** are used by nine of our LFM initiatives to procure energy within a predefined time window. Six of these LFM initiatives that apply continuous trading do so in the intraday (ID) timeframe, while the other three procure from DA to ID. Among the LFM initiatives that apply continuous trading, some have indicated that they are considering procuring flexibility during certain fixed time slots, approaching a closed-gate auction approach.

- **Closed gate auctions** is the type of market clearing used in 50% of all the surveyed LFMs. However, there seem to be some variations in the way closed gate auctions are applied. For instance, one of the surveyed LFM initiatives that currently applies a closed gate auction, indicated that in the future, they could proceed towards multiple sequential auctions. Another initiative applied a reverse auction in which FSPs bid against each other to make a service available at the lowest price in an open order book. At a fixed time, the DSO buys its requirements from this order book.

- **Bilateral trade** is applied by one initiative, but in this case, it is specifically used for its capacity limiting contracts and flexible connection agreements.

Six of the surveyed LFMs make use of a combination of clearing mechanisms depending on the product procured (Euroflex, FinFlex, Fluvius Local Congestion Market, GOPACS, OneNet Northern Demonstration in Finland and Sthlmflex). These initiatives tend to choose for tenders for their LT ahead procurement, while continuous and closed gate auctions are chosen for ID and DA procurement. Nevertheless, across all surveyed LFMs, it appears that CGAs are generally used for longer time horizons compared to continuous markets. Six out of 32 surveyed LFMs that apply a CGA procure flexibility more than a week ahead and 11 out of 32 procure flexibility on a DA basis. In contrast, most LFMs with continuous markets apply ID procurement (8 out of 15). However, it is to be pointed out that in a significant number of cases, the timing of the market is still to be decided by the SO (e.g. 10 of the 68 products).

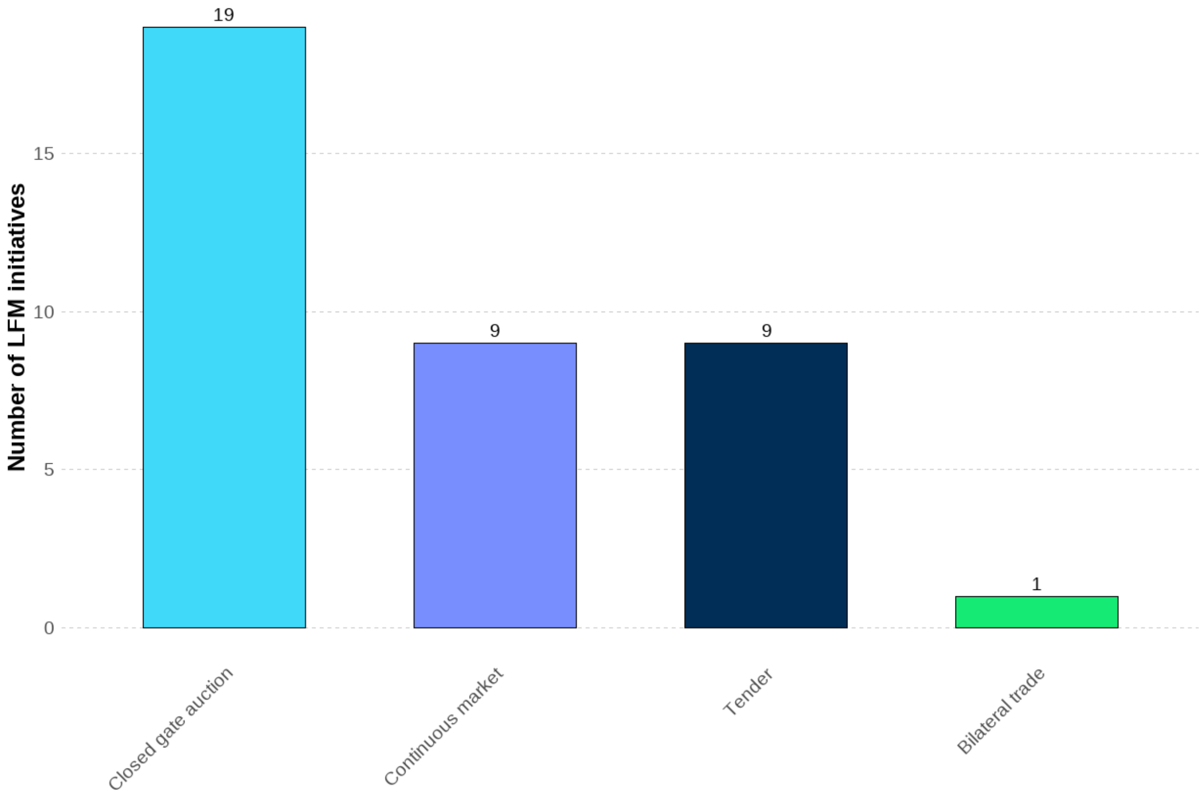


*Figure 2-21: Clearing mechanisms applied by the surveyed LFM initiatives (Source: VITO own figure).*

**Final bid selection**

The characteristic "final bid selection" examines whether the final bid selection is completely automated in the surveyed LFM initiatives or whether there is still an intervention or check from the procuring SO for the selection of the final bids. In the latter case, we refer to the bid selection as a manual bid selection. Previous research on LFMs has also discussed the role of the procuring SO in the final selection of bids. In contrast to other wholesale markets (e.g., day-ahead, intraday, and balancing) that have a completely automated market clearing or matching processes, there are specific reasons in LFMs that typically suggest a need for some level of intervention or verification by the procuring SO before the final market outcome is confirmed. Some of the key reasons, as outlined in [17], include: (i) alternative solutions should be weighed against LFM-based flexibility, such as technical solutions on the DSO side (e.g. network reconfiguration) and other mechanisms, such as flexible connection agreements, to ensure the most cost-effective and optimal combination of solutions is used, (ii) DSO involvement might be needed to account for planned or real-time network conditions, such as maintenance activities or outages, which cannot always be fully and easily considered in the market clearing process, and (iii) finally, there are concerns regarding the extent of network data that can be incorporated into LFM market clearing, highlighting the need for SO oversight to verify the resolution of the grid's flexibility needs as well as to safeguard the rest of the grid. Furthermore, it is also highlighted that sharing data implies the need to update those data in multiple locations.

<u>Insights from the surveyed LFMs</u>
Bid selection in surveyed LFMs is in about half of the cases not fully automated. In about 40% of the surveyed LFMs there is SO intervention, which can range from simple final checks or full manual bid selection by the SO outside the market platform.

Despite the fact that a lot of initiatives apply closed gate auctions and continuous trading as discussed above, it is to be noted that in eight of the 31 surveyed LFM initiatives, there is a manual **final bid selection step**. Unlike spot and balancing markets, the market clearing is therefore not always entirely automated.

As visualised in Figure 2-22, there are different variations in how bid selection is done. In almost half of the cases, a complete automated market clearing is pursued. However, in the other half of the cases, SO intervention is possible. As highlighted by the green colour in the pie chart, in one fourth of the LFM initiatives, the final bid selection is done explicitly by the SO himself. The following observations could be made:

- **Completely automated**: About half of the surveyed LFMs have a fully automated bid selection process. Bids are selected automatically through a matching algorithm on the trading platform, with no human intervention required. An automated matching algorithm offers the benefit of ensuring a transparent, fair, and non-discriminatory selection process. Some LFM initiatives that use automatic matching argue that no further SO check is necessary, as prior checks during the qualification process ensure that only FSPs meeting DSO requirements are allowed to bid. Some of the more advanced and experienced LFM initiatives express confidence that their automated approach operates effectively without manual intervention. This confidence stems from their use of internal SO tools that provide insights into forecasts, dispatch information, and more. Based on these insights, the aforementioned internal tools help the SO to set the right requirements within the LFM, thereby improving and supporting the automated bid selection process.

- **Final check by SO**: In some cases, the market is almost run automatically, however, in the end, some verification or check is done by the procuring SO. One surveyed LFM initiative indicated that this is required as accepting the market outcomes results in a SO engagement to remunerate the FSP. This requires human intervention, as it formally involves signing a contract. In several of the surveyed LFM initiatives, SO checks are conducted for internal learning and training purposes, or for testing purposes, as the demo is still in pilot mode and there is a need to ensure the ability to intervene if something goes wrong. Furthermore, in some of the surveyed LFM initiatives, the market platform performs an initial selection and transmits it to the procuring SO, including, for example, a priority order - but without revealing offer prices. This allows the SO to perform a final check to ensure the proposed services comply with grid limitations. Based on the SO's input, the platform then identifies the final accepted and rejected offers, which are subsequently published and communicated to each market participant. In some LFM initiatives, the platform by default presents the final platform outcome to the SO for final approval.

- **Bid selection by DSO**: In some LFM initiatives, bid selection is entirely handled by the DSO, potentially through manual processes. Initiatives opting for manual approaches argue this is necessary due to the currently limited need and thus value of local services. It is also important to keep IT development costs low. It is argued that since grid congestion is still relatively rare, full automation is not essential yet. However, if the markets are scaled up, automation would be desirable, provided it can be implemented cost-effectively. Some initiatives that currently apply manual bid selection also indicated that automation is under review or that some sort of semi-automated solution with a recommended outcome and some limited manual adaptations is envisioned in the future. One initiative intervenes in the market outcome during capacity procurement by reviewing the merit order set by the market platform. It verifies the list of capacity offers by evaluating combinations of availability and maximum utilisation remuneration information already provided by the FSPs, accounting for various probabilities and scenarios of future anticipated activations. This is done entirely outside the market platform, although in theory, the platform could operate fully automatically. Finally, some initiatives simply take the admissible offers listed by the market platform and process them through an internal DSO system algorithm to select the final bids.

- **Fully automated, except for LT procurement**: Finally, it should be noted that five mature initiatives have for at least one of their products an automated matching, and for at least one product a manual DSO bid selection (E.ON Energy Networks Sweden, Effekthandel Väst, Sthlmflex, UKPN LFM). From the surveyed LFMs, it is clear that bid selection of seasonal availability products or capacity products in general is more likely to be done manually as tenders are published or auctions are opened ahead of time and the numbers of FSPs, and related offers are typically limited. For energy products, however, they utilise more automated algorithms. We zoom further in on this topic in section 2.3.3 on the roles and responsibilities.

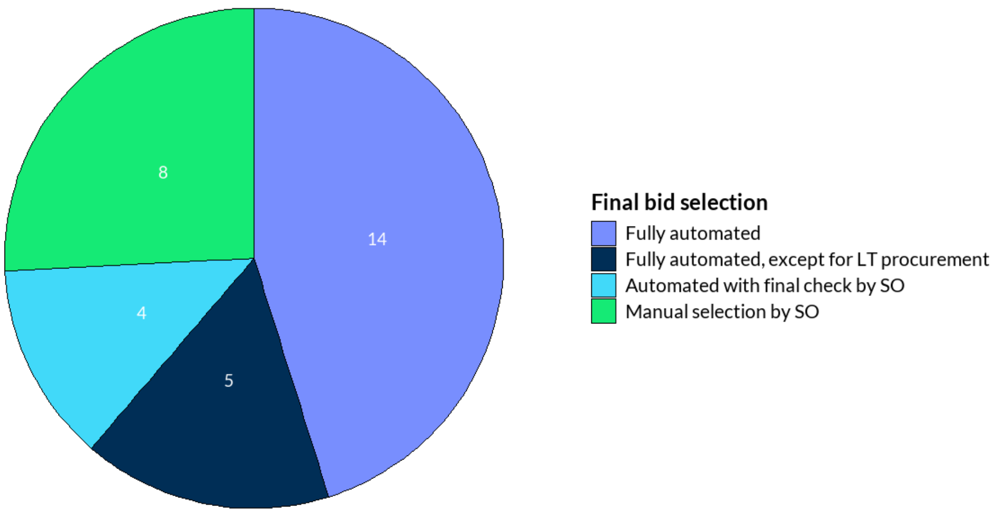


*Figure 2-22: SO involvement in final bid selection in surveyed LFM initiatives (Source: VITO own figure).*

#### Network representation in the market

With regard to ensuring the effective resolving of the grid's flexibility needs, we also consider as part of the classification framework how **LFMs can include a network representation** in their market clearing formulation and algorithms to model how the flexibility procurement (and, thus, subsequent activation) affect the power flows over the different parts of the network. Differently from conventional balancing markets, which do not necessarily need a network representation as their objective is to ensure that upward or downward regulation needs are met in an aggregative way (possibly considering available tie-line capacity in cross-border applications), markets for congestion management or voltage control require a level of network representation in their market-clearing problem formulation, e.g., see [28], [29], [30], as the ability to meet the local grid needs depend on the resulting changes to the power flows and voltages of the system, which in turn result from the modified injection and offtake at different nodes in the system via the activation of flexibility. We consider the following broad types: **Market area based on network information, Representation based on impact factors, Simplified network models**, **Advanced network models.** In BOX 2, the interested reader can find more details on these different types of network representations. A summary of the four approaches to network representation in the market is provided in Figure 2-23.

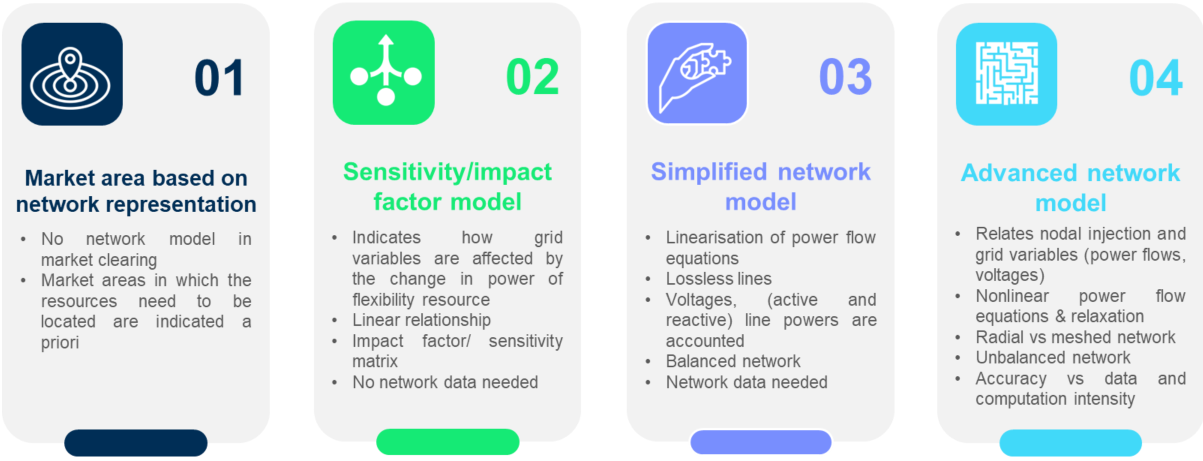


*Figure 2-23: Type of network representation in the market applicable in the context of LFM (Source: VITO own figure)*

*BOX 2: Theoretical overview of the types of network representation in the market*

A physical representation of an electrical network is typically given by static power flow equations. These equations represent the relationship between injected/withdrawn (real and reactive) powers at the busses with bus voltages (magnitudes and angles) and/or line power flows (real and reactive). Through these equations, one can evaluate the changes in the bus voltages and line power flows when the net-injections at different (combination of) busses are modified, as is the case in flexibility provision. Specifically, for radial and balanced distribution networks, an alternative formulation called the branch flow model was proposed initially in [31] and has been intensively studied in the literature as, e.g., in [32]. However, due to the nonlinearity of these equations, including power flow equations into a market clearing problem, e.g., as in [30], might render the problem intractable. Therefore, typically, in the literature of optimal power flow problems, these equations are relaxed. Two popular non-linear relaxations that have been studied quite intensively are the second-order cone relaxation of the branch flow equation and the semidefinite relaxation [33]. The second-order cone model is used to represent distribution systems in the clearing problem for a TSO-DSO coordinated market in [34], [35] and an LFM [36]. These network representations can be classified as **advanced network models** since they significantly increase the computational complexity of the market clearing problem.

To enable a market clearing problem to be posed as a linear programming problem, supporting its computationally efficiency and tractable solution (as is the case, e.g., in wholesale markets that also incorporate network representations, such as the PJM market in the USA [37]) a linear network representation (a **simplified network model**) is often preferred in the LFM literature. In this regard, for transmission networks, a linear approximation of the power flow equations is typically accepted. The most common linear approximation, especially for transmission systems, is called the DC power flow model[5], where the reactive power, line losses, and the shunt elements are neglected, while the

[5] The DC is a common nomenclature to indicate this MW-only linearized power flow representation, as it resembles DC power flow equations [38]. However, it is not intended to mean that the used current is a direct current (DC).

magnitudes of the bus voltages across the network are assumed to be approximately equal to 1 per unit (p.u.)[6] and voltage angles at different buses to be small [39], [40], [41]. As an example, the DC power flow representation in a transmission-level flexibility market clearing can be found in [28], [35]. On the other hand, in a distribution system, nodal voltages are typically not equal, albeit strictly bounded, and hence, cannot be neglected. Therefore, in this case, the linearised branch flow model, which includes reactive powers and voltage magnitudes, and which is typically dubbed the LinDistFlow model, has been proposed. Indeed, the market-clearing formulations for distribution-level LFMs in [28], [42], [43], [44], [45], [46] use this model. Furthermore, [29] shows that this model is good enough as its performance approximates the nonlinear second-order cone approximation of the branch flow model.

Differently, a sensitivity matrix, such as the power transfer distribution factor (PTDF), can also be obtained to represent a linearly proportional relationship between two grid variables, e.g., between injected powers at certain nodes and line power flows on (critical) lines or between injected powers and nodal voltages [47] (**sensitivity factor/impact factor model**). In other words, a sensitivity matrix translates, in a linear manner, how changes to net injections at different nodes (real or reactive power) would affect the power flows (real or reactive) at different lines or voltage magnitudes at different nodes. The PTDF representation is a special case of such sensitivity matrices linking real power injections to lines' real power flows and can be directly derived from the linearised DC power flow equations [39], [41]. Although this model is more common for transmission networks, even beyond flexibility markets as is the case in, e.g., interconnected wholesale energy markets [28], [42], including those with flow-based market coupling [48], [49], some works on LFMs, such as [18], [23], [50], [51], [52], [53], consider this model for distribution systems. A specific sensitivity-matrix-based approach that has been developed in several flexibility market projects is the impact factors model, which shows a linear relationship between the flexibility (in terms of power) of a resource to the injected or line powers in the network [50]. Technically, PTDFs can be derived from the linearised power flow equations at a given operating state of the grid [54], [55], or can be derived numerically based on a linear regression process [56], [57]. It is worth noting that although impact factor models and simplified models are both linear, impact factor models require less information about the network to be integrated in the market clearing than simplified models. Specifically, the former do not need the topology of the network and network parameters, such as line resistances, while the latter do.

Finally, it is worth noting that a network representation is not needed in the market clearing problem when the flexibility needs (in terms of power adjustment) at all the nodes have been pre-calculated and, thus, the market simply needs to consider balancing equations (**no network representation**). While the calculation of the nodal flexibility needs requires a network representation, the market clearing problem, under this setting, would no longer require a network representation. A number of papers on LFMs, e.g., [58], [59], [60], [61], consider this formulation. The paper [61] even develops a methodology for flexibility request calculations for LFMs that takes into account a network representation, thus no longer requiring a network representation as part of the market clearing.

Thus, the requirement of a network representation can also depend on the operational conditions of the network. In stressed conditions, more network information may be needed to make sure that the flexibility procured is sufficient and that it does not endanger any other parts of the grid, while when the needs are very localised (e.g., at transformer level) while other parts of the grid have enough capacity, the network representation requirements can be reduced, to just quantify the impact of flexibility activation from

[6] p.u. denote Per Unit and is a relative measure in power system that allow expressing a certain quantity (e.g., voltage magnitude) as a fraction of a reference "base" value [39].

different areas of the grid on the local congestion conditions to be resolved (e.g., loading of the transformer). This network representation can also be considered ex-ante to create flexibility requirements from different areas of the grid, thus not requiring network representation during the procurement/market clearing phase.

Insights from the surveyed LFMs
Network representation is in three-fourths of the LFM initiatives only limitedly accounted for in the market. It is argued that network representation is indispensable, yet currently it is often not yet integrated into the market and is instead accounted for by the procuring SO outside the market. In the future, a move towards more gradually complex representations is anticipated.

As visualised in Figure 2-24, three-fourths of LFM initiatives have limited network representation in the market. They are more likely to roughly define a market area in which resources need to be located, before the procurement takes place. This can be done based on e.g., postal codes, drawing a shape around a collection of nodes, etc.

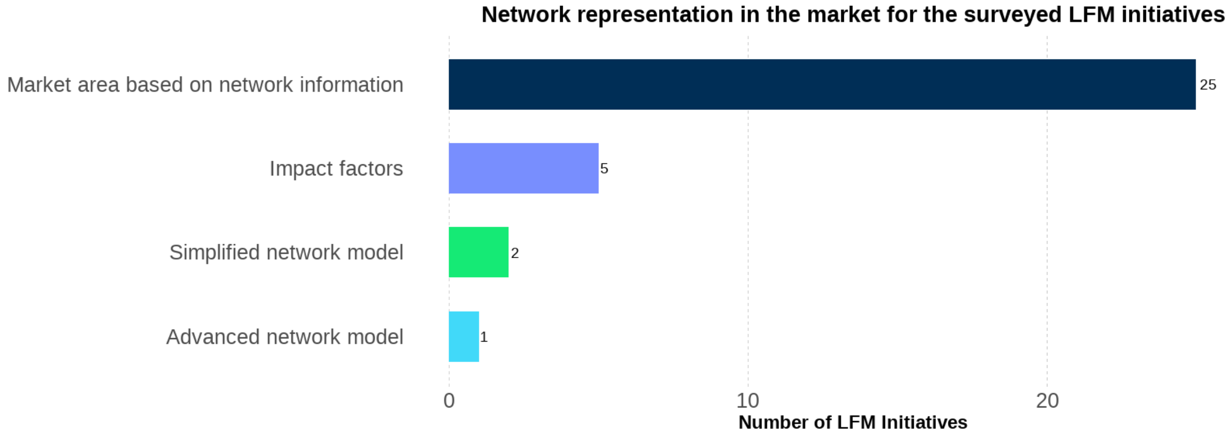


Figure 2-24: Network representation in the market for the surveyed LFM initiatives (Source: VITO own figure).

Of course, in this case, more advanced network analysis is often performed outside the market sphere by the procuring SO. In these cases, a detailed network representation is not included in the market clearing itself. Initiatives agree that proper network information is essential, as it is necessary, among other things, to validate whether the bids can solve the SO need. However, such validation is currently mostly done outside the market. It is claimed that, unlike in balancing services, this validation is 'definitely needed' for local services. This is also confirmed by the results of the poll in the SO-workshop as presented in Figure 2-25.

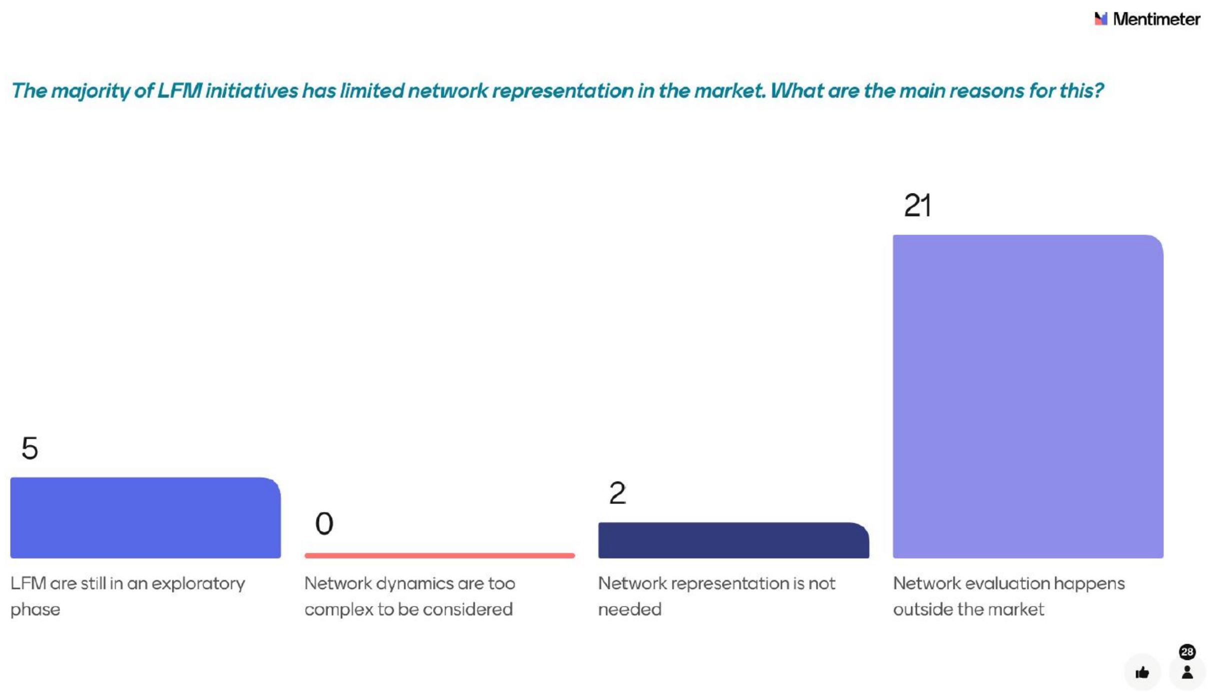


*Figure 2-25: Poll results on the underlying reasons for limited network representation in the market for LFM during the SO workshop (Source: SO workshop).*

21 of the 28 participants are in favour of more abstract representations in the market and/or SO only network analysis outside the market[7] for a number of closely linked reasons. First of all, generally, and especially at lower voltage levels, available grid information is limited. In addition, even when this information is available, this information is often static and not necessarily up to date. Furthermore, when information is available, it is not always possible to share it with the market. This may be due to the complexity of sharing large volumes of data from an IT perspective, and ensuring it remains up to date across multiple locations. Alternatively, data sharing may simply be restricted for grid security reasons. Alternatively, during the workshop it was also highlighted that sharing data is, on some occasions, not allowed for confidentiality reasons (e.g. when there are only few consumers on a line). In cases where limited information is available, SOs rely on their internal knowledge and experience of the grid, particularly for localised issues. This allows them to define abstract market areas based on previous experiences. Finally, a concern was raised that when network representation in the market is too detailed, it could lead to a lower transparency in market outcome and would add computational complexity to the market clearing.

During the MO-workshop, it was indicated that this more abstract grid representation did not yet lead to issues in flexibility procurement. This is, among others, because SOs can adapt their market area on the platforms accordingly when needed. Nevertheless, some platform providers are already receiving requests from SOs to include more advanced network representations in the market. Yet, these come in slowly as today SOs are still in the process of developing and learning. There is a concern from the platform providers and the SOs that the requirement to have a more detailed grid representation in the market could be a barrier to start an LFM. It was highlighted that, in the short run, it is

[7] This means that the network evaluation is not part of the market platform but performed by the DSO outside the market with using internal DSO tools.

important to kick-off a market, even with a simple network representation. For the longer run, LFM initiatives are investigating more advanced options.

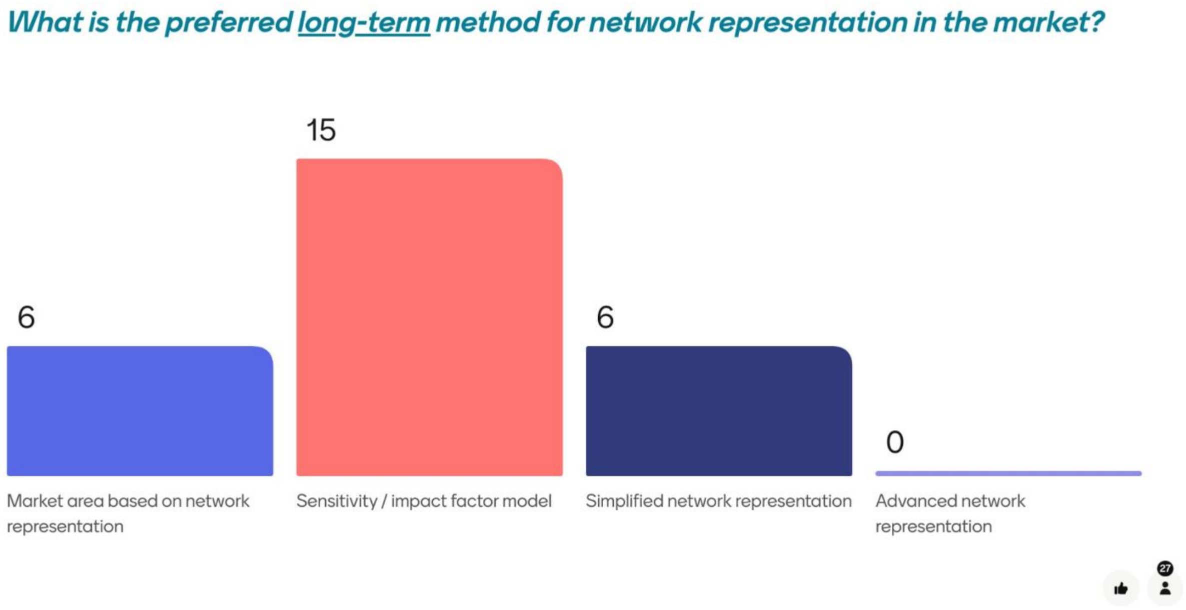


*Figure 2-26: Poll results on the preferred LT method for network representation in the market during the SO workshop (Source: SO workshop).*

The poll in the SO-workshop (Figure 2-26) indicated that in the long-run, initiatives would prefer more detailed network representations such as the sensitivity/impact factor models, or simplified network representations. Advanced network representations were not indicated as feasible LT solutions. Indeed, the LFM initiative in Figure 2-24 that used a more advanced network representation in the market was a pilot running a simulation. In summary, during the workshops, it is therefore concluded that in terms of grid representation, pragmatic, more step-by-step approaches seem to be preferred: starting simple and gradually increasing the complexity as experience and capabilities grow. Furthermore, it was noted that there is no significant push on this topic, and that progress towards more advanced type of grid representations would occur more slowly than initially anticipated.

As visualised in Figure 2-24, five LFM initiatives have applied an **impact factors model**. Although most of these initiatives consider that the impact factors are static, (i.e., they are calculated only once, only the Hungarian Flex.ON initiative is updating their impact factors regularly based on the actual network state before the market is cleared). The impact factor calculation itself is mostly performed by the procuring SO and it is typically done through some form of load flow analysis, which can be computationally complex. Finally, models that belong to the classes of **simplified and advanced network representations** have only been implemented in three LFM pilots (the OneNet Northern Demonstration in Finland implemented an advanced network representation in the market clearing, the FEVER LFM in Anell's grid and Industry4Redispatch implement a simplified network representation). In this case, some network data, including the topology of the network and some network parameters, such as line impedance, are needed. Commonly, the participating SOs must provide their network constraints, which include a network representation, to the market platform, which will integrate these constraints into the market clearing problem.

**Pricing arrangements**

Another important consideration during the procurement phase is the structure of the pricing arrangements. The **pricing scheme** in an LFM determines how flexibility providers are compensated, with models such as pay-as-cleared, pay-as-bid, locational pricing, or mixed pricing. The LFM review in [62] finds that pay-as-bid is more widely applied in LFMs. Additionally, **bidding price limits** may be applied, setting maximum or minimum allowable prices for both capacity and energy procurement, which can be applied per bid (as has been, e.g., the case in day-ahead markets and balancing markets) or collectively on the total procurement cost [18], thus enabling, in the latter case, the SO to compare the total flexibility procurement cost resulting from the LFM to other alternative flexibility procurement options. This allows the SO to opt for other options, which may be needed in nascent LFMs, with scarce flexibility and existence of potential market power.

<u>Insights from the surveyed LFMs</u>
40% of the surveyed LFMs make use of bidding price limits, increasing transparency on SO willingness to pay to enhance participation levels. Almost all surveyed LFMs make use of a pay-as-bid pricing scheme.

The **pricing scheme** applied is in most cases **pay-as-bid:** for capacity remuneration, 12 out of 16 products made use of pay-as-bid, and for energy remuneration 27 out of 29 cases made use of pay-as-bid. The pay-as-bid mechanism allows for easier locational pricing that reflects specific grid constraints and is more straightforward in less liquid markets. However, one initiative also opted for **pay-as-cleared** (e.g. Cypriotic OneNet pilot). Furthermore, one initiative also applied **fixed availability payments** for some products for the whole period (e.g. E.ON Energy Networks Sweden). In the latter case, FSPs do compete on the activation price (pay-as-bid). Furthermore, an initiative proposed that contracts between the market and the FSP could define the activation price using a standardised pricing formula (e.g. GOPACS).

On top of the pricing scheme, 40% of the surveyed LFM initiatives defines a **bidding price limit** as visualised in Figure 2-27. However, the majority does not define a bidding price limit and some LFM initiatives have not decided yet on what they will do. The surveyed initiatives indicated that bidding price limits ensure that SOs do not overspend, as the flexibility cost cannot be higher than the usual investment costs. Furthermore, the surveyed initiatives point out that, as many LFMs are still immature, FSPs have limited experience in determining their bidding prices. Indicative prices or bidding price limits can therefore help guide them. It should be noted that the discussion on including bidding price limits is closely linked to the discussion on sharing information, specifically the extent to which the SO wishes to share information on the value of flexibility, for instance through the maximum price they are willing to pay, as will be explained in more detail in section 2.3.2. In some of the surveyed LFM initiatives, whether a bidding price limits is set depends on the type of products. For instance, in one initiative the SO can choose to include a maximum price for capacity products, but they are obliged to do so for energy products. Finally, in some countries, the regulation influences the bidding price limit, setting the methodology on how to determine this limit. It should be noted that some initiatives are very transparent about how they determine the maximum price they are willing to pay. UKPN, for instance, bases itself on a standard cost-benefit analysis (CBA), which considers the cost of expanding specific grid elements, such as a substation.

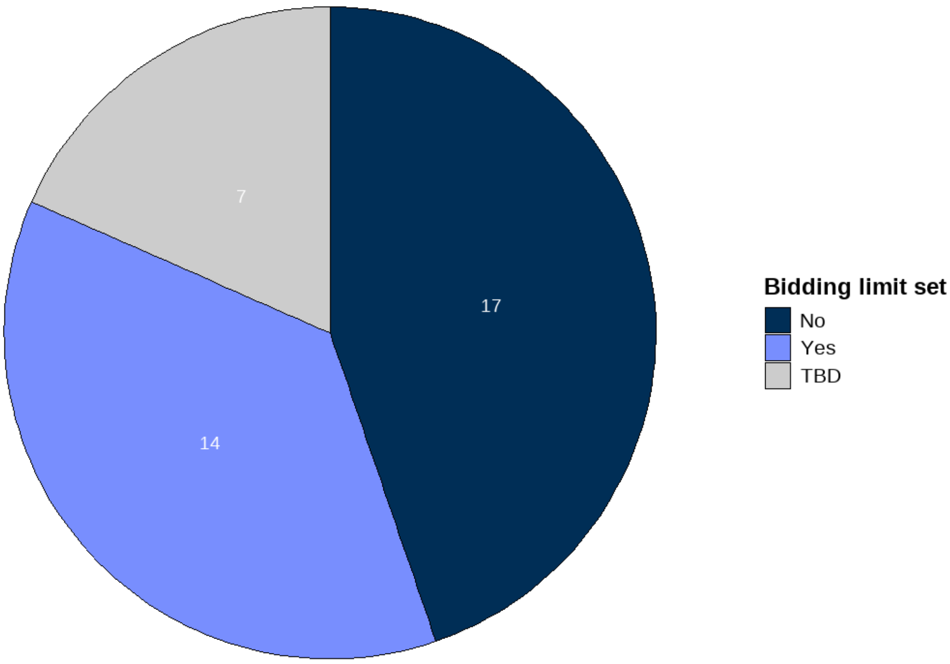


*Figure 2-27: Presence of bidding price limits in the surveyed LFM initiatives (Source: VITO own figure).*

**Market time unit**

Another key aspect of the procurement phase classification is the market time unit, which defines the period for which the flexibility remuneration price applies.

The market time unit for the surveyed LFM initiatives, is generally 15 or 60 minutes. Some initiatives explicitly indicated that they originally used e.g. an hourly time unit but are now moving towards 15 minutes or plan to do so in the future.

#### 2.2.3.3 Activation

This part of the classification structure examines how activation is handled across different LFM initiatives. It includes when activation is confirmed, whether it is performed manually or automatically, and the channels used for activation.

**Mode of activation**

The mode of activation of bids, can be manual or automatic. Automatic activation is done automatically and is often referred to as direct control, whereas a manual activation is done at the request of the SO.

Insights from the surveyed LFMs
Most surveyed LFMs rely on manual activation of flexibility, where the FSP ensures timely response to activation signals for planned local services, while only a minority use automatic activation, typically in pilots or reactive power markets where SOs or platforms control assets directly.

Since local services are mostly planned well in advance (e.g., forecasted congestion events during specific hours), the surveyed LFM initiatives predominantly rely on manual activation. In these cases, the FSP is responsible for ensuring the timely activation of assets upon receiving the activation signal. Only a minority of the surveyed LFM initiatives apply automatic activation, in which case the DSO or the market platform directly controls the FSP's assets. This setup allows the DSO / the market platform to activate the assets within an agreed upon time period. We find examples of this, for instance, in a reactive power market where the FSP requires a DSO telecontrol cabinet to receive the setpoint sent directly by the DSO to activate the asset (e.g. Fluvius RP market). Another example with direct asset control took place for testing purposes in a pilot, where the DSO sends formal control signal through the platform, but activated the assets directly in the pilot. Furthermore, it should be noted that there are also LFMs (such as the LFM in Ljubljana) that allow for both manual activation and direct control, as aggregators have controllers on heat pumps. However, they indicated that there are still technical barriers to direct control, as there is not yet sufficient harmonisation among household appliances. The wide variety of smart apps, home energy management systems, and smart heat pumps makes automation difficult.

**Communication requirements**

This part of the classification structure zooms in on the method of communication between the SO and the FSP to trigger activation.

Insights from the surveyed LFMs
Most of the surveyed LFMs use automated signals. In a minority of the cases, manual activation signals are sent through phone calls or emails.

As mentioned above, the surveyed LFM initiatives mostly apply manual activation at the request of the procuring SO. Various communication methods are used in this case. However, in 21 surveyed initiatives some sort of automated signal is sent (through SCADA systems, API, MQTT, 4G signals…). In that case, an automatic signal is sent by the DSO system or the market platform to the FSP. In three initiatives, the SO simply picks up the phone to call an FSP to check availability or instruct activation. Finally, there are also 6 initiatives that make use of a hybrid system, meaning that the signal can be sent both in an automated or a manual way. It should be noted that, especially in case of automated systems, that multiple communication options could be possible, depending on the FSP's preferences and the type of flexible resources they manage (for instance, apart from API signal, information signals could also be sent through SMS or email). There are also alternative approaches towards activation signals, for instance, for its product without capacity reservation, one of the surveyed LFM involves the DSO calling FSPs to check availability before issuing an activation request. In that case, the FSP can refuse the request without penalty. Over time, this LFM indicated they might evolve to other schemes, however, right now the key purpose is to keep it simple as they don't have a lot of congestions yet.

In the case of automatic activation, a communication link is required between the SO and the asset. One LFM initiative mentioned having access to a physical switch on the flexible assets, while another initiative uses telecontrol setpoints which are sent to the flexible assets, which then respond accordingly.

**Activation timing**

This part of the classification framework describes when an activation signal is sent. Some LFM send explicit activation signals, while for others the publication of the market outcomes entails an implicit activation. A distinction can be made between direct activation and scheduled activation:

- In the case of scheduled activation the timing of activations is known in advance once the LFM is cleared and no additional activation request is sent.

- In the case of direct activation, the activation request from the procuring SO can be issued to the FSP at any point in time in the agreed time window activations can occur.

Insights from the surveyed LFMs
Activation timings in LFMs typically ranges from day-ahead to near real-time, with some initiatives applying direct DSO control or scheduled activation, where delivery timing is predefined and no separate activation signal is required.

The activation timings are already presented in Figure 2-20. As discussed above, around half of the LFM initiatives activate flexibility between the day-ahead stage and one hour before delivery, while others do so closer to real time. Some of the latter include direct DSO control. In some cases, scheduled activation is applied, meaning that the timing of activations is known – often well in advance – and based on the market outcome. In those cases, there is no explicit activation signal as a delivery schedule was already communicated beforehand.

#### 2.2.3.4 Settlement

Settlement forms the backbone of LFM operations, as it determines how flexibility services are quantified, verified, and remunerated. It encompasses a range of interlinked processes - from defining baselines, to verifying delivered flexibility and managing metering, invoicing, and penalties. Ensuring accurate and transparent settlement is particularly challenging in LFMs, given their diverse actors, distributed resources, and data requirements/availability. This chapter explores how settlement is organised across different LFMs, highlighting approaches to baselining, verification procedures, measurement standards, and payment mechanisms. Finally, it examines whether and how the impact of flexibility actions on the BRP and supplier is addressed in the initiatives.

**Baseline methodologies**

A baseline refers to a counterfactual position (of the consumption or injection level) of a flexibility resource if they had not activated their flexibility [63]. It is used as a reference with respect to which to measure the flexibility volume that is delivered by a flexibility resource (or aggregation thereof) and a crucial element of flexibility markets that procure flexibility services (deviation of the consumption/injection position from the reference), as opposed to services that are based on capacity limitations, which require capacity limits [64]. Large-scale generators participating in wholesale and system-wide flexibility markets, such as mFRR and aFRR, can typically consider their schedules from the wholesale markets as their baselines. However, distribution-level FSPs might not have such schedules and, thus, a methodology must be put in place to estimate their baselines. Baselining methodologies commonly used in practice can be categorised into the following approaches: (i) **meter-before-meter-after (MBMA), (ii) historical data approaches, (iii) zero/fixed value baseline, and (iv) nomination (self-declared) methodology** [63], [65]. An in-depth review of baselining methods can be found in [63], [66], [67] while their applications to existing markets and pilot projects are listed in [67], [68]. In BOX 3, a brief discussion of the previously mentioned categories of baselining methods based on the previously mentioned references is provided.

BOX 3: Baseline methods

The **MBMA** method obtains a baseline from a single meter reading before the period of activation, or by taking the average/median/maximum/minimum value of several meter readings before the period of activation, and comparing these measurements with the reading after the period of activation [63], [65]. This method is easy to implement and based on real-time data. It is effective for flexibility products with frequent but short periods of activation and suitable for delivery points with relatively flat offtake/injection profiles during the activation period [65]. However, this method is highly susceptible to gaming behaviour (baseline manipulation), which can be reduced if the activation directions are not announced ahead of time in automatic flexibility activation applications.

Differently from the MBMA, which uses real-time data, a baseline can also be estimated based on historical consumption data (and other external data) using a statistical method. These types of baselining methods are classified as **the historical-data approach**. This category is the largest, as different statistical methods have been proposed for baseline calculation. The most common and the simplest methods in this category are averaging-based methods, such as (high, middle, or low) **XofY** and rolling average. In these methods, a baseline is obtained by averaging the generation/consumption measurements at the same metering point from selected several days in the past, during the same time periods and during days of the same type (e.g., weekday vs. weekend) during which no flexibility activation has taken place. For example, under the high XofY method, a baseline is obtained by averaging the meter reading of X days, which have the highest consumption among Y eligible previous days. Note that the middle XofY takes the X middle measurements and low XofY takes the lowest measurements. These methods can be applied to different directions of flexibility activations: upwards or downwards. Meanwhile, the rolling average simply takes a (weighted) average of several previous days. Frequently, a same-day adjustment, i.e., taking into consideration the measurement of the past hours, is used to calibrate the baseline, as well as adjustment techniques that put more weight on more recent days/time periods. These methods have been widely used in the US and European markets, dominantly for long-duration products [65], [69]. For instance, the mFRR market in Belgium uses the high XofY method [70]. Similar to the MBMA, the averaging-based methods are simple. Performing manipulation to this method is possible although not as easy as for the MBMA method, e.g., as demonstrated in [69]. More advanced statistical methods have also been used and/or proposed to improve the baseline accuracy, e.g., regression and machine learning methods, which use not only consumption/generation profiles but also external data, such as weather and locational data. The US ERCOT system is an example that uses this method [65], [67]. These methods require a significantly higher amount of data and computational load than the averaging-based methods. Thus, there is a trade-off between simplicity and accuracy when using a historical-data approach. Historical approaches, especially machine learning based ones, can also be adapted to situations in which the flexibility source is not directly metered, so adjacent measurements are taken to estimate the baseline [63].

**The zero/fixed-value baseline method** essentially means that the baseline is obtained based on a known operating value. It is a technology-specific baseline methodology, for example for back-up generators, which are normally not operated (thus, zero baselines). This method can also be suitable for electrical storage systems (ESSs), considering that the storage system is dedicated only to providing flexibility during a flexibility activation period. In this case, the baseline of the storage cannot be manipulated, thus it has a high level of integrity, unlike other baselining methods, e.g. MBMA, which can be prone to manipulation if applied to an ESS as its operator can momentarily switch the power direction [63].

Finally, baselines can be nominated by FSPs upon the request of the MO (**the nomination method**). In this case, an FSP can use any method(s), at its own discretion, to obtain its nominated baseline, implying the accuracy can vary from one FSP to another depending on the forecasting capability. This approach is suitable for products whose activation time is close to the request time [65], but opens up baseline manipulation concerns and thus requires a form of monitoring [63].

Insights from the surveyed LFMs
Baseline methodologies in LFMs are seen as challenging, with most initiatives supporting multiple approaches. Simpler methods are often preferred to encourage participation or

nomination baselines are used to allow FSPs to propose their own baseline, though capacity-limiting products are also used to avoid baselines altogether.

Figure 2-28 presents the different baseline methodologies supported by the surveyed LFM initiatives, categorised according to the proposed classification structure. In terms of baseline methodologies, all of the surveyed LFM initiatives indicate baseline methods as a challenging topic. Some initiatives even still need to decide on their baseline method(s), and some of the initiatives that have selected a method indicate that they are not always convinced it is the most effective and efficient choice. There is a trade-off between using more accurate, complex baselines and opting for more feasible, understandable ones. Multiple surveyed SOs have made similar observations: it is important that FSPs clearly understand how they are likely to be compensated. Complicated baselines that focus solely on accuracy can reduce transparency and, as a result, discourage FSP participation. In such cases, simpler baselines may be preferred over more accurate ones. Furthermore, it is argued that simpler baseline methods can facilitate the participation of users without advanced communication equipment. It is worth noting that most of the surveyed initiatives support more than one baseline methodology, as the diversity in methods is considered necessary due to the diversity in services and flexibility providers.

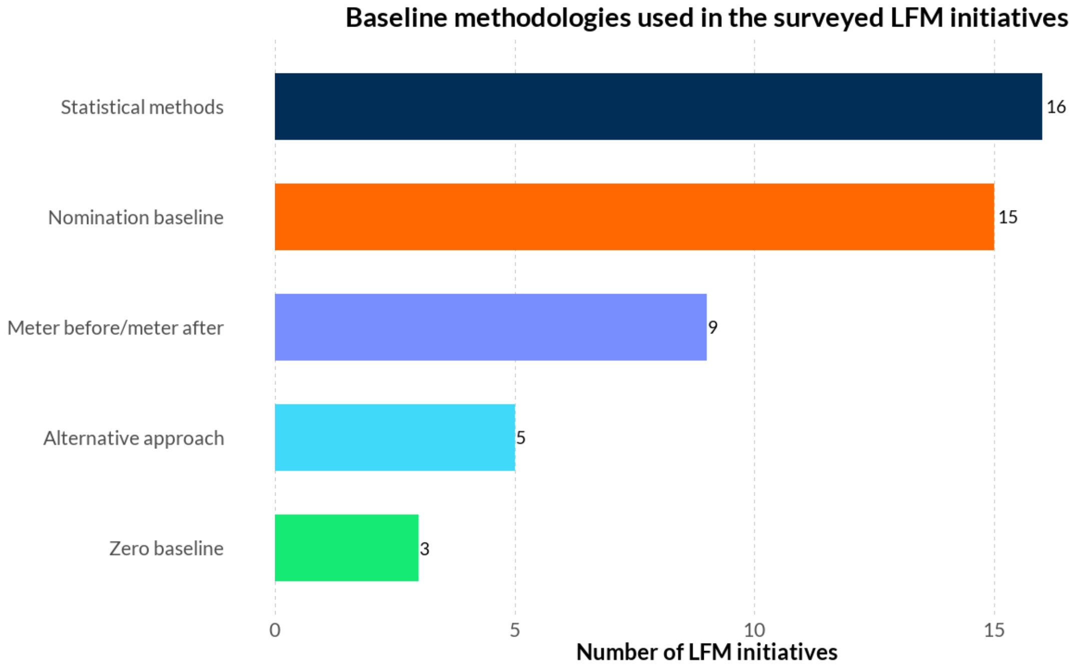


*Figure 2-28: Baseline methodologies used in the surveyed LFM initiatives*

Various approaches are used to select a baseline method across the surveyed LFM initiatives. Some initiatives adopt standard or agreed-upon baselines, particularly in regions where multiple SOs have coordinated on common baseline approaches. Other initiatives aim to align with existing markets (e.g., balancing markets) to make participation simpler and more transparent for FSPs. This is also clear from the figure above, showing that most initiatives rely on statistical methods to determine their baselines. This typically means baselines are calculated using metered data from previous days or hours—for example, by averaging the most representative eight days out of the last 10. Depending on whether delivery occurs on a weekday or weekend, historical data from similar days (i.e., weekdays versus weekend days) may be used. Some LFM initiatives however raised concerns about these methodologies in the context of LFM and are investigating alternatives as mentioned above.

A significant amount of the initiatives therefore chooses for the nomination baseline, implying that the FSP can propose its own baseline. Alternatively, some of the surveyed LFMs predefine baselines from which the FSP can choose. This flexibility enables FSPs to select the most appropriate baseline depending on their assets. As a result, multiple baseline methods can be applied per FSP, tailored to the technologies they represent. For example, when flexible resources like batteries or backup generators are used, devices that are either on or off, the zero-principle baseline is often recommended (e.g. UKPN LFM, E.ON Energy Networks Sweden, Enedis LFM). However, even the zero-principle baseline has limitations. It only works effectively if the battery is active exclusively for the LFM. This means that in the absence of activation, both injection and withdrawal should be zero. Such a condition only holds when the battery is dedicated solely to the LFM or has been awarded availability for certain hours and is therefore restricted from participating in other activities during those times.

There are also initiatives that offer additional functionalities, allowing baselines to be calculated through the flexibility register, for example, based on historical data. When FSPs can suggest their own baseline methods, DSOs often have the right to request an audit or a verification on the selected method.

Finally, some initiatives have also opted for an alternative product on top of their other products which does not require a baseline, (e.g. Fluvius AP LFM, Effekthandel Väst). Instead, they implement a capacity limiting product, which limits the capacity that the FSP is allowed to consume or inject. Furthermore, Flex.on Hungary LFM only uses these types of products and Enedis LFM also allows for alternative baselines (including the capacity limiting approach) . A key argument in favour of this method is that it eliminates the need for a baseline, resulting in a more transparent and straightforward validation process. It has been argued that setting baselines is particularly challenging in the context of LFMs, where there is a wide variety of flexibility providers, often small in scale and with less predictable behaviour compared to larger participants in more established markets. In the case of capacity-limit-type of products, no baseline is required; only the capacity limit - e.g., defined in the form of a schedule -needs to be set. Afterwards, actual measurements can simply be compared to the limit to verify compliance. Finally, the Irish Demand Flexibility Product also does not require a traditional baseline approach, as the FSP needs to operate its assets within an operating envelope.

Apart from the baseline method itself, some of the surveyed LFM initiatives also impose additional baseline rules and conditions; such as:

- Baselines must be uploaded a certain time before the delivery time or within another specified time window.
- FSPs are not allowed to adjust baselines after the activation request.
- The calculation method for the baseline must be submitted to the SO for approval. Only approved methods may be used by the FSP to generate their baseline.
- To verify the baseline, a minimum amount of historical data may be required before the first delivery, allowing the SO to assess the proper functioning of the method.
- In some cases, baseline-related data must be provided on a continuous basis (i.e., for all hours of all days), not limited to service periods or delivery blocks.
- The FSP must undergo an audit trail of its chosen baseline method, ensuring that the DSO can check and verify stated baselines and associated calculation methods.

**Verification method**

We will also describe the method used to verify whether the FSP complies with the promised flexibility delivery. This is typically done by comparing the baseline with the measured profile, but other methods may be applied when a realistic baseline cannot be determined. In such cases, an alternative method can be used to estimate the delivered flexibility. One such proposed method is the **"drop-to" approach**. In this case, specific capacity limits are set. This approach is typically associated with capacity-limit products, as discussed in [64], [71], [72] and falls, as indicated in the section above, under the "alternative baseline approach".

<u>Insights from the surveyed LFMs</u>
Most LFMs verify FSP compliance by comparing measured data to the baseline or capacity limits, with validation handled either by the platform or SO.

There is limited variation in how different LFMs verify FSPs' compliance with their promised flexibility delivery. In most cases, compliance is assessed by comparing the baseline with measured data. These data are either collected by the trading platform - which automatically compares the measurement data with the baseline - or by the procuring SO, who then validates the service provision and communicates compliance to the market platform. For the LFM initiatives where capacity-limit-type products are used, the actual measured profile is just compared with the set capacity limit to check compliance as explained above.

**Measurement requirements**

To verify delivery, measurement data are required. The metering requirements for verification and settlement are therefore examined, including whether connection meters and/or submeters are used for these purposes. There are some variations across the surveyed LFM initiatives in how data is measured and in the types of meters used:

- **Smart Connection meter / AMR measurements**: where available, already existing smart meters are the preferred measurement method as this is more convenient and easier for both the FSP and the DSO.

- **Sub-meter**: However, some LFM initiatives require or allow the use of sub-metering. Sub-metering can be used to monitor large or individual assets located behind the main meter, thereby avoiding the masking of compensation effects. For example, it may occur that one asset delivers the promised flexibility, while another behaves in the opposite direction. Without a sub-meter, the SO would not be able to detect this. Some initiatives also allow sub-meters as a fallback option when an asset cannot be validated through a smart meter.

In addition, it should be noted that in some LFM initiatives aggregated measurements at FSP portfolio level can be used for the verification of service delivery. This is for instance the case in the Fluvius AP LFM initiatives, where metering values at portfolio level coming from the FSP need to be uploaded on the market platform (i.e. within 48h after the delivery block), while keeping an audit trail of its measurement data and underlying data sources to ensure that the underlying data can be verified if needed - for instance, during compliance checks or audits. Additional conditions further apply, as specified in the product specifications. Some other LFM initiatives do require verification and settlement at individual flexible resource level. For instance, in the Swiss Opentunity pilot, for the assets which are directly controlled.

**Measurement time unit**

The measurement time unit, is the smallest time interval over which consumption/injection is measured and recorded. The **frequency** of the data measurement differs from minute-based readings (e.g. BiTraDER) to quarter-hour measurements or half hourly measurements (e.g. UKPN). In most cases (over 60%), however, 15-minutes configurations were used. In certain cases, the measurement resolution may be selected flexibly, ranging from one minute to the market time unit used as the basis for settlement. Finally, some initiatives also adapt to FSP meter possibilities. For instance, Euroflex requires 15 minutes data measurements, but does allow 60-minutes data measurements if not otherwise possible.

**Invoicing and payment**

This paragraph addresses invoicing and payment across the various initiatives, outlining how, when, and by whom FSPs are compensated for flexibility services. This is handled differently across initiatives. In some cases, both activation and reservation payments are processed monthly. For example, one initiative specifies that invoices are issued 12 working days after the end of the delivery month, with a payment term of 30 days from the invoice date. While the different roles involved will be discussed in more detail later in this report, it is worth noting that, in some cases, payments are made by different entities. For instance, penalties may be invoiced by the SO, whereas regular payments are handled by power exchanges or MOs. Finally, in some pilot projects, the invoicing and payment phase has not yet been implemented, or invoicing is not fully automated, requiring manual processing. This contrasts with initiatives using commercial platforms, where invoicing and payment are more likely to be automated.

**Penalties**

In addition, we checked whether certain **penalties** are applied by the LFM initiatives in case of partial or non-delivery to ensure compliance with contractual obligations and maintain market reliability. These are imposed on FSPs when they fail to deliver the agreed-upon flexibility. Penalties in the context of LFMs are typically financial consequences. In such cases, payments to FSPs may be reduced based on the deviation between the promised and actual flexibility delivery, or additional financial fines may be applied. Various predefined formulas can be used to calculate the penalty, similarly to those for balancing service provisions, e.g., as explained in [73]. Other approaches may also be implemented. For instance, FSPs with poor performance could face restrictions on future market participation.

<u>Insights from the surveyed LFMs</u>
Today, most LFM initiatives do not apply explicit penalties for partial or non-delivery, as these initiatives are still emerging and overly strict financial consequences risk discouraging potential participants. Five initiatives have implemented (or are considering) explicit penalties for non-delivery. Another eight LFM initiatives have adopted well-thought-out penalty schemes that typically include pro-rata payment systems based on delivered volume, combined with minimum and/or maximum thresholds - without imposing additional explicit penalties.

Five initiatives give (or are considering) **explicit penalties for non-delivery**. More specifically:

- One initiative considered **exclusion from market participation** in case non-delivery happens on a repeated basis (e.g., in case of negligent performance in multiple market procedures, the FSP may be excluded by the SO from further participation in future market sessions).

- One initiative applied **financial penalties for non-delivery,** while another one is considering it. For the former, if the FSP fails to deliver the agreed-upon flexibility, it shall pay 50% of the compensation it would have otherwise received under the contract. In case they only deliver partially what they promised, they shall pay 20% of the cost that they would otherwise have received. Reasons for such penalties are linked to the fact that it is important for the DSO that a high certainty and reliability of the services is realised.

- In some cases there are **specific regulations that determine the penalty**. For instance, in the Netherlands, there is a regulatory congestion non-delivery penalty outlined in Article 9.36 of the Dutch grid code [74]. In Lithuania, the DSO is required to use the public procurement portal, which also determines the contract type and associated penalties.

However, in most cases, the surveyed LFMs do not (yet) apply such penalties. A key reason for this is that they are still in the piloting phase and/or do not want to demotivate FSPs who are also still gaining experience on how to deliver flexibility in the best possible way. They want to encourage participation as they need flexibility now. As such, they do not want to scare FSPs. However, instead of explicit penalties, most LFMs apply **reduced payments for partial delivery**. This implies that the FSP only receives payments proportionately to the amount of flexibility delivered. However, eight LFM initiatives adopted a more advanced approach. The surveyed LFMs reported the following methods:

- **Threshold delivery required to receive full payment**: this implies that FSPs receive full payment only if they deliver at least a specific percentage of the requested flexibility; otherwise, no payment is given. One of the LFM initiatives with a capacity-limit-type product applies a variation of this approach, i.e. the FSP must achieve the promised power limitation on at least 40% of the contracted delivery blocks. If this standard is not achieved, the FSP loses its right to compensation on the totality of all its contracted delivery blocks.

- **Payment scale based on delivery percentage**: this implies that payment scales are defined based on delivery percentage, influencing how FSPs are compensated. For instance, one LFM initiative offers full payment in case of at least 95% delivery, reduced payments for 40-95% delivery and no payment if delivered flexibility is below 40% of the promised flexibility. The initiative combines a minimum delivery threshold for payment eligibility with a payment scale proportional to the delivery percentage. We have seen this approach in several LFM initiatives. In one initiative, this can also be beneficial, as payment scales up to a maximum of 115% for over-delivery. In this case, a minimum threshold of 85% is applied to qualify for any payment, which can then scale up to 115% (e.g. if an FSP delivers 105% of what was proposed, they will receive a 105% payment). However, in all other LFM initiatives, over-delivery is not compensated.

- **Deduction of payment based on performance**: this implies that the FSPs activation fee is reduced according to a set formula. One initiative applies a certain formula based on the delivered flexibility % ($L$):

  - If $L$ ≥97%, the FSP receives 100% of its activation fee ($Pcontract*A$, where A = activation price for delivery block).

  - If $L$<97%, the AV (activation fee) is calculated as follows: $AV=Pcontract*A*$ (100%- 2. 5(100%-$L$)).

- **Hybrid**: In some cases, combinations of all the above penalties apply depending on how much has been delivered. As such, the DSO can allow for some degrees of non-delivery, while penalising very low delivery more severely. Penalties and compensation strategies can also differ between products and services.

Quite some LFM initiatives that did not apply a penalty scheme yet agree upon the fact that there should be consequences in case of non-delivery or in case of not following the agreed-upon schedules. However, in the short run, for most of them, it is not clear yet, how they will align these penalties with their market rules.

**Aggregation model**

The participation of (small-scale) distributed flexibility in LFMs typically requires a form of aggregation by the FSP, in which multiple small-scale resources are steered to participate in the LFM and deliver the required flexibility. The role of the FSP can be integrated or independent. In the integrated case, the FSP's role is claimed by the supplier of the flexibility asset owners. Under **independent aggregation** (IA), the FSP is a different party than the supplier or BRP of that supplier. The flexibility activation actions taken by the IA would, however, impact the BRP and supplier in two ways [75], [76]: (i) *imbalance impact*: the flexibility activation actions impact the balancing positions of the BRP, thus risking imbalance costs/penalties; (ii) *foregone revenue*: the flexibility activation actions by the IA modify the consumption profiles of the consumers, impacting their electricity consumption, and thus, the potential revenues of the supplier. As such, the FSP/IA, by carrying out flexibility activations to achieve financial benefits, may in turn harm (or, in general, impact) other market parties [77], [78]. To address these two elements, respectively, two concepts have been proposed: (i) **perimeter correction**, and (ii) **financial compensation**. Perimeter correction [75], [79] is a mechanism in which the BRP's position is adjusted to consider the planned activation of flexibility by the IA, thus avoiding the impact thereof on the BRP. Financial compensation is a mechanism in which the IA compensates the supplier for the revenue foregone due to flexibility activations, or equivalently, a mechanism that neutralises the financial impacts of flexibility activation on the supplier. These mechanisms typically fall under what is called **independent aggregation models**. For more details, we refer to BOX 4.

*BOX 4: Independent aggregation models*

Several independent aggregation models have been proposed in practice and in the literature. For example, the Universal Smart Energy Framework (USEF) has characterised seven different independent aggregation models covering different options of contractual relations between the supplier, BRP, and the IA/FSP [79], [80].

In general, independent aggregation models can be split into 4 main categories [75]: (1) the **uncorrected model**, which includes no perimeter correction and no form of financial compensation, (2) the **perimeter adjusted model**, which includes perimeter correction for imbalances but no form of financial compensation for the supplier, (3) the **central settlement model**, in which perimeter correction is adopted and financial compensation to the supplier is implemented based on a developed formula designed by a central entity (e.g., national regulator) and applied uniformly to all activated flexibility, and (4) the **corrected model**, in which perimeter correction for imbalances is adopted, and the financial impacts on the suppliers are avoided by correcting the metered data of the consumers eliminating the impact of flexibility activation on the invoiced energy. The need for such correction mechanisms is not always implied, as the impacts on the BRP and the suppliers from flexibility activation by the IA is not always negative. In addition, flexibility activation typically leads to a shift of (net) consumption to other time periods (known as the rebound effect), which does not necessarily lead to foregone revenues by the suppliers.

This aspect has been thoroughly analysed in [75]. Indeed, the work in [75] has provided a European benchmark for the implementation of different IA models, and provided a quantification of the impact of flexibility activation as well as the implementation of different aggregation models on all stakeholders involved, namely: the supplier and its BRP, the IA/FSP, the consumer, and the SO. By identifying the value transactions, [75] highlighted that the impacts of flexibility activation on each stakeholder is governed by four key dimension: (1) the flexibility activation direction, (2) the imbalance prices (sign and volume), (3) the service delivery price (sign and volume), and (4) the day-ahead market prices and their translation to retail prices under dynamic retail contracts (sign and volume). In addition, those impacts should be tracked not only at the time of activation, but also over a period of time to identify cumulative effects (including rebounds).

Insights from the surveyed LFMs
Balance corrections or supplier compensations are rarely implemented in LFMs, as their complexity is seen as disproportionate to current market volumes; most initiatives prioritise core market design and liquidity over the implementation of such mechanisms.

Generally, balance correction for BRPs or financial compensation for affected suppliers is not frequently implemented in the surveyed LFM initiatives. A key reason is that, in some countries, such mechanisms are not yet in place - although many are currently discussing or considering them. Additionally, some initiatives argue that implementing such mechanisms in LFMs is not (yet) justified due to the relatively low volume of procured services. As a result, BRPs and suppliers are barely affected by current (pilot) LFMs. For some initiatives, this is not required due to the trading times; trades conducted before the day-ahead market do not affect BRP portfolios or suppliers, provided that the relevant FSP informs them.

Furthermore, it was argued that adopting a correction model is complex and depends on digital infrastructure investments, among other factors. As such, its implementation in LFMs should be based on a thorough evaluation and cost-benefit analysis. There is broad agreement among the surveyed LFM initiatives that the primary focus should be on developing a market design that achieves its core objectives (e.g., ensuring market liquidity). Mitigating potential negative impacts on the BRP/supplier in case of IA is generally considered a lower priority and should definitely not overcomplicate the market design. Finally, questions have been raised about the net impact - both in MWh and euros - on the BRP or supplier after a full season of congestion activations. It should be carefully considered whether the proposed solutions are proportionate to the actual net effects observed.

Nevertheless, there are also initiatives that do recognise that some corrections need to be in place, however, they do not yet have a solution for it. One LFM groups flexible resources per BRP, correcting trades according to the imbalance settlement. However, as independent aggregation models are not yet sufficiently implemented in their country, there is no financial compensation foreseen. Furthermore, another initiative indicated that it did not apply balance correction but informed the affected balancing groups about imposed power limitations, enabling them to adjust their positions if needed.

In total, from the surveyed LFMs, three initiatives have compensations in place. Two initiatives use the same mechanism as in the balancing market according to the stipulated rules. Another initiative balanced and nominated activations against the participating BRP portfolios but did not have compensations in place for suppliers.

#### 2.2.3.5 Gaming

LFMs have at instances been criticised for a claimed susceptibility to strategic behaviour and gaming. Some aspects that have been studied in the literature in relation to LFM are (i) the **existence of market power** due to scarce liquidity; (ii) increase-decrease (inc-dec) gaming; (iii) baseline manipulation; and (iv) double commitments/activation. These four aspects of gaming are illustrated in Figure 2-29, along with proposed mitigation measures. In BOX 5, the interested reader can find a more detailed explanation.

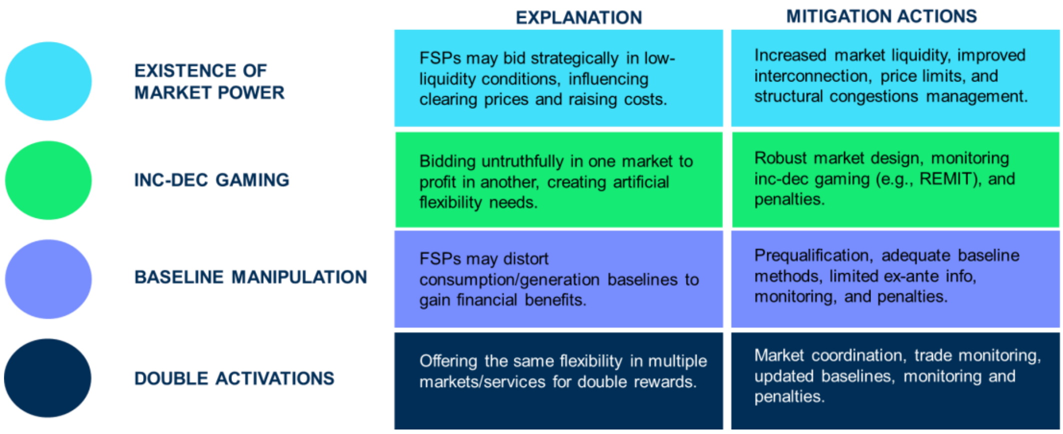


*Figure 2-29: Gaming risks and mitigation actions in the context of LFMs (Source: VITO own figure).*

*BOX 5: Gaming risks and mitigation actions*

**Market liquidity**

FSPs may bid strategically in low-liquidity conditions, influencing clearing prices and raising costs, thus exerting market power. This low liquidity setting can stem from different dimensions: (i) **the nature of local services**: local services (congestion management, voltage control) require flexibility resources in specific grid locations, which can limit the volume of potential flexibility providers, leading to scarcity and limited liquidity; (ii) **market maturity**: nascent markets can have low initial FSP participation, enabling a limited number of FSPs to potentially exert market power; (iii) **flexibility market design** and **TSO/DSO coordination** challenges: flexibility market fragmentation can limit the use of flexibility across different grid areas, which limits the pool of FSPs available for different SOs (e.g., disjoint/fragmented flexibility markets, in which each SO procures flexibility from resources only within its area of control, limits the ability of flexibility from other grids to participate, thus discarding their liquidity-improving potential); (iv) **grid restrictions**: structural grid capacity restriction, similar to market fragmentation, may also limit the ability to use flexibility across different grid areas, which limits the number of FSPs that can provide the needed grid services for different SOs (e.g., limited TSO-DSO interface capacity that would limit the potential of distribution-level flexibility resources from providing TSO-level services). These elements, as they decrease market liquidity, pose the risk of increasing the potential of exerting market power and gaming. Indeed, the papers [53], [81], [82], and the report [16] show that FSPs can have incentives to bid strategically instead of truthfully (truthful, here, signifies bidding at marginal costs) in various (local) flexibility markets, including TSO-DSO coordinated markets. When FSPs bid strategically, some can exert **market power** and steer the clearing price, under certain market situations, thus increasing the procurement costs. When a LFM is decoupled from other markets (market fragmentation), the existence of market power can become more likely [81], as shown for instance in [83] and [84], where strategic bidding of distributed energy resources and storages is studied. Some actions that can be imposed to deal with such behaviour include supporting market participation, enabling cross-grid flexibility participation through TSO-DSO market coordination/cooperation and adequate cross-grid network capacity, as well as flexible price limitation/indication in nascent markets.

**Inc-dec gaming**

The inc-dec gaming behaviour constitutes a setting in which market actors participate in successive markets, where they act in the first market in such a way to cause artificial needs to be resolved (by those same actors) in the following market, thus reaping financial benefits. The base use case on which inc-dec gaming was first explored has focused on strategic arbitrage in zonal wholesale day-ahead markets followed by a market-based congestion management (re-dispatch) stage, through which the participation in the DA market is carried out to create grid services needs (e.g., intrazonal congestions), which can be resolved in the following re-dispatch stage [85]. As such, a market player can bid in the day-ahead market untruthfully, knowing that extra profit can be obtained from the second market [82], [86]. This process can also apply to LFMs, in terms of creating artificial flexibility needs in them (similar to the standard inc-dec gaming, capturing a setting of an energy market followed by a flexibility market). In this respect, flexibility needs are artificially created (i.e., congestion is aggravated) by players implementing inc-dec gaming[8]. The authors of [88] identify that this behaviour occurs due to inconsistent market designs (e.g., zonal in the day-ahead market and locational in the flexibility market), leading to different price formations between the successive markets. It is also worth noting that this behaviour is independent from market power [88]. Some recommendations to avoid and/or mitigate such behaviours are [89]: having transparent, competitive, and robust[9] market designs in addition to providing explicit rules against inc-dec gaming. It is also crucial to have robust monitoring activities, i.e., monitoring baselines and prices [90], [91], [92], based on multiple approaches, such as using historical data and a control group, to identify inc-dec gaming from persistent differences in schedules on days with and without congestion. As a result, if harmful inc-dec gaming behaviour is observed, then direct sanctions, ranging from fines, cost-based remuneration, to a ban, can be imposed [92]. The paper [93] argues that network tariffs, as a compensation for the lack of nodal pricing in day-ahead markets, can help mitigate this behaviour. This paper also discusses that some market regulations can be imposed to deal with inc-dec gaming. Specifically, fixing offer prices throughout the day can reduce the potential of inc-dec gaming in a real-time market. Furthermore, [93] also suggests that a cost-based compensation, instead of a market-based one, can be used when excessive market power and arbitrage opportunity are likely to occur.

**Baseline manipulation**

Baselines can also be susceptible to gaming behaviour (**baseline manipulation**). For instance, when the MBMA method is used, an FSP can strategically modify its consumption/generation level momentarily when the measurement before the activation is taking place. Similarly, under a historical-data baselining method, FSPs can manipulate their consumption/generation profiles in the period of non-activation in order to generate (inaccurate) baselines, which can be profitable for the FSPs. It is worth noting that manipulating historical-data-based baselines can be rather difficult for the FSPs, especially in comparison to the real-time-data-based ones. For instance, [69] shows that a flexibility provider needs advanced methods and stochastic models to be able to gain profit. In addition, [69] provides an indication of an optimal gaming behaviour that can be observed for a particular averaging-based baselining method, useful for the identification of such manipulations. Baseline monitoring and tracking measures can be implemented to detect strategic baseline behaviour [90]. Particularly for nomination baselines, to incentivise true baseline reporting, [94] proposes random baseline check, i.e., at random instances, some market participants are called to provide flexibility and others are obliged to feed into the grid according to their reported baseline and are penalised for deviations. Unfortunately,

[8] Despite capacity-based redispatch, i.e., where the remuneration is based on the reserved capacity instead of energy activation, is being proposed to avoid inc-dec gaming behaviour, the authors of [87] show that such a mechanism is not effective as market players can still behave strategically, aggravating redispatch requirement and, thus, increasing the operational cost.

[9] In case of insufficient liquidity, system operators have access to additional backup resources that are under cost-based redispatch [89].

there is only a limited number of works in the academic literature that discusses this problem and how to effectively identify and deal with this gaming behaviour.

**Double commitments and activations**

With the existence of multiple flexibility markets and venues for flexibility valorisation, another activity/behaviour that an FSP can take advantage of is engaging in double parallel commitment or double activations. In both situations, an FSP offers the same flexibility in multiple markets for double the reward. For the case of double commitment, that can refer to offering capacity in multiple markets. In the case of double activations, this constitutes receiving multiple rewards for the same amount of flexibility activated. In both situations, an FSP then bids in multiple markets using the same bids (i.e., from the same flexibility assets). If their bids are selected in more than one market and activated, they will be remunerated twice for activating the same flexibility resource. In some LFM pilots, FSPs are allowed to submit flexibility bids using the same flexibility resources/assets to different markets, and it is the responsibility of the FSPs to avoid double activation [95]. One key important measure that is suggested to prevent double activation, as mentioned within multiple reports [96], [97], [98], [99], [100], is having proper coordination between procuring SOs throughout the market phases. Practically, SOs need to exchange information on merit order lists/selected flexibility volumes [97], [98]. Furthermore, a coordinated mechanism for the verification and the settlement phase is also needed [98]. Such measures can be achieved when there exists good interoperability between market platforms [99]. In addition, integrating planned activations in forecasting exercises of the SOs and baseline calculations for the FSPs would provide additional clarity, avoiding the double remuneration of activated flexibility.

For the different LFM initiatives we checked: i) whether any strategic behaviour has been observed, and ii) whether any mitigating actions are in place.

<u>Insights from the surveyed LFMs</u>
Gaming risks are considered minimal by the LFM initiatives, with actual instances reported as rare and often unintentional. While baseline manipulation is recognized as a potential challenge, many initiatives report strong FSP commitment rather than strategic misuse. However, it should be noted that monitoring remains limited, meaning that the LFM initiatives may be unaware of some gaming behaviour. Several initiatives also acknowledge that their pilot phase or limited data availability may prevent a comprehensive assessment of gaming risks at this stage.

**Strategic behaviour**

In the surveyed LFM initiatives, few gaming risks were identified, and instances of actual gaming were found to be rare according to the initiatives. In addition, during the MO-workshop, some of the commercial market platform providers explicitly pointed out that they have never seen real-world evidence of inc-dec gaming occurring. Some examples of gaming behaviour were attributed to unintentional mistakes by FSPs according to some of the LFM initiatives. Initiatives that spotted in the beginning some gaming (with prognoses and baselines), discussed this with the specific FSPs, as such coming to a solution. However, baseline manipulation has been mentioned as a challenge to account for. Finally, some initiatives are reporting the opposite of gaming, indicating that engaged FSPs are so committed to delivering the service effectively, as such negatively affecting their own baseline as they started the delivery of the service too early.

However, it must be pointed out that in surveyed LFM initiatives also indicated that gaming is often not a consideration yet due to the piloting and testing phases of LFM initiatives. It was also highlighted that market immaturity leads to a lack of data, making it difficult to make proper observations and/or monitor the problem to take appropriate action.

In Germany[10], since the ending of the ENERA project in 2020, LFM development was significantly slowed down due to a fear for gaming. This was primarily due to the fact that the emergence of market power and so-called "inc-dec gaming," or strategic bidding behaviour, were concluded in the ENERA project to present two fundamental challenges that must be addressed and resolved when implementing LFMs. German initiatives that are setting up new LFMs, however, state that those risks are manageable. This is among others based on recent statements in a study conducted by E-Bridge Consulting GmbH [101][11].

**Mitigation actions in place**

This part of the classification structure zooms in on the mitigation actions in place to cope with strategic behaviour. This can include a combination of robust baseline verification, market monitoring & audits, penalties for non-compliance, and market/product design improvements.

Insights from the surveyed LFMs
Given the low perceived gaming risks and the early stage of LFM development, few initiatives have implemented mitigation measures, prioritising functioning markets and liquidity over complex safeguards; where applied, solutions focus on market design, monitoring, auditing and information control.

Given the currently perceived low gaming risks and the current immature status of LFMs, only a limited number of the surveyed initiatives does apply mitigation actions against gaming behaviour as they are procuring for very localised constraints, which possibly leads to less liquid markets, as visualised on Figure 2-30.

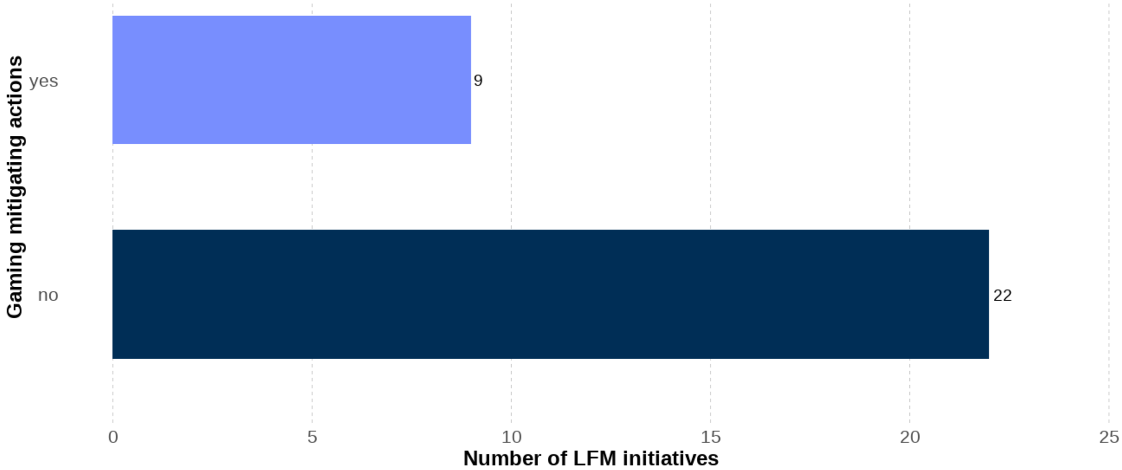


Figure 2-30: Presence of mitigation actions in surveyed LFM initiatives (Source: VITO own figure).

The surveyed LFM initiatives that have mitigation actions in place, indicated to have implemented different solutions to mitigate different gaming risks, ranging from market design, regulatory and platform-based technological solutions:

[10] More information on the German context can be found in Annex 2 (description of Germany).

[11] The study aims to establish a framework for integrating decentralized, small-scale load flexibilities, particularly in the low-voltage grid, into redispatch processes through a pilot phase of PKME (Pilotierung des komplementären marktbasierten Engpassmanagements)

- A **proper and robust market design** ensuring trading windows for different products do not overlap, with rules ensuring that FSPs cannot offer the same capacity of their resources in several markets at the same time (preventing double activation/acceptance), with expiring bids after acceptance, making use of bidding price limits and proper baselines methods.

- **Limiting information sharing** e.g. information on the size and location of flexibility, pricing information, etc.. Some LFM initiatives claim that sharing this type of information could encourage gaming behaviour. We discuss this in more detail in section 2.3.2.

- **Market surveillance,** which includes monitoring by SOs or MOs. In this context, it was also emphasised that different assets exhibit different flexibility characteristics, and therefore exhibit varying gaming opportunities and behaviours, which necessitates tailored verification and monitoring approaches. In GOPACS, for instance, each grid operator verifies delivery of flexibility and monitors gaming through the platform. Market surveillance can, among others, also include **monitoring of baselines** (e.g. as done in Effekthandel Väst, Sthlmflex). In Euroflex, there is a requirement to submit continuous baseline and meter reading time series also for hours outside of contracts. The MO can then monitor baselines and meter readings to discover anomalies. In the RomeFlex LFM, the settlement process was checked.

- The inclusion of a **right-to-audit** clause or similar contractual arrangements between the FSP and the SO can ensure that the SO is entitled to audit the FSPs, verifying that no gaming has occurred or is occurring (e.g. UKPN LFM).

As a final, and frequently returning argument and concern, it was indicated that it is too early to worry about gaming. The surveyed LFMs and platform providers indicated that it is more important to set up a functioning market with enough liquidity, rather than to overcomplicate the market. Even initiatives that monitor for gaming point out that they are more concerned about creating markets that are too rigid or "un-gameable", if doing so makes participation unnecessarily difficult.

## *2.3 Governance*

The fourth category of the classification structure focuses on governance, where we cover: i) coordination aspects between SOs and with other existing markets, ii) information sharing, and iii) main roles and responsibilities.

### *2.3.1 Market coordination*

Market coordination in LFMs concerns the interaction and alignment between different SOs and other market players, and markets to ensure efficient, effective, safe, and non-conflicting use of distributed flexibility resources. As LFMs mature, coordination across institutional and market boundaries becomes increasingly important to prevent conflicting activations, maximise value stacking, and promote market efficiency. This chapter explores how coordination is organised at multiple levels - between TSO–DSO, among DSOs (DSO–DSO), and across markets and products. It also discusses enabling mechanisms such as bid forwarding, harmonised market design, and coordinated procurement processes. Together, these elements determine how LFMs integrate within the broader electricity market architecture, shaping their scalability, interoperability, and overall contribution to system optimisation.

**TSO-DSO coordination**

Currently, TSOs have established and operate markets to procure flexibility for balancing services, such as mFRR, aFRR, and FCR. In such markets, bids from flexibility resources in distribution systems can be submitted. With the addition of LFMs, distributed flexibility resources have multiple avenues for participation. At the same time, the DSOs and TSOs must have some form of coordination when procuring and activating flexibility resources, especially those that participate in multiple markets, i.e., LFMs and TSO-level (balancing) markets. The main advantages of this coordination lies along three dimensions: i) **maximising value staking potential**, wherein the different FSPs can capitalise on the fact that a certain flexibility offered can be used to provide multiple services, ii) **grid-safety**, wherein an SO procuring flexibility from resources connected outside its control area, may cause operational challenges in those grids, thus rendering coordination crucial to prevent such risks and iii) **cost optimisation for grid operation**, where thanks to coordinated or common procurement of flexibility, the overall cost for system operation might decrease. When TSOs and DSOs engage in joint procurement of flexibility, then coordination would also be required in the allocation of costs (settlement) of the jointly procured flexibility, as investigated in [42]. This part of the categorisation structure therefore discusses how the coordination between TSO and DSO for the procurement of flexibility and grid security guarantees is arranged.

In terms of **coordination for market-based procurement of flexibility**, different market schemes have been proposed and studied in the literature, e.g., [28], [102], [103], and in different European large-scale demonstration projects such as H2020 CoordiNet and H2020 Onenet [16], [104], namely: (i) separate SO markets, (ii) sequential DSO-TSO markets, and (iii) common DSO-TSO markets. We summarise these in Figure 2-31. The interested reader is referred to BOX 6 for a more detailed discussion on these models.

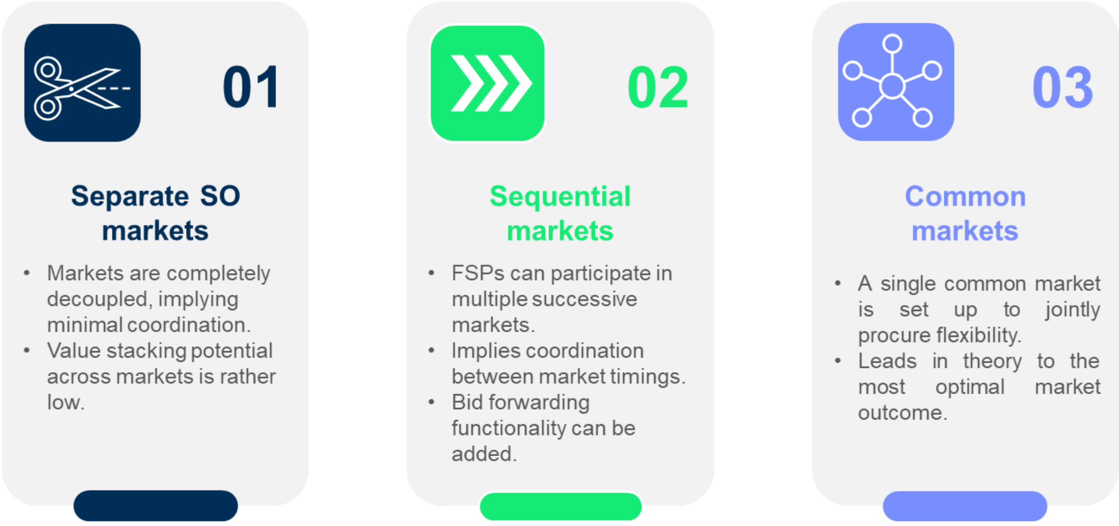


*Figure 2-31: Overview of market models applicable in the context of LFM (Source : VITO own figure)*

*BOX 6: Overview market coordination schemes*

In the first scheme (**separate SO market**), markets are completely decoupled, wherein, each SO procures flexibility solely from flexibility resources connected to its own grid, implying minimal coordination between markets. Therefore, the value stacking potential of the flexibility resources is low [102].

In the **sequential DSO-TSO market** scheme, distribution-level flexibility can participate in multiple markets in a successive manner (e.g., a DSO market layer for congestion management, followed by a TSO market layer for congestion management and/or balancing), which by extension requires at the current stage coordination between LFMs and existing balancing markets. Different coordination sequences (e.g., DSO markets followed by TSO markets or vice versa) and processes might be implemented, as discussed in [102], [105]. These types of sequential markets can also differ with the level of information available to the FSPs when deciding to engage in each market, wherein a difference is drawn between a setting in which an FSP observes the results of a certain market before engaging in the next, and a settings in which this is not the case, thus requiring, in the latter case, the FSP to decide how much of its flexible capacity to bid in each market [16], [52], [104].

Differently, in the last scheme (**common DSO-TSO market**), a single common market is set up by different SOs (DSOs and TSOs) to jointly procure flexibility for their needs. Although the common market scheme has the best theoretical market efficiency [28] – stemming from its ability to collectively procure flexibility from a common pool of resources considering all grid constraints, thus maximising value stacking potential – rendering it highly advocated in literature, e.g., in [34], [35], [106], it faces practical implementation challenges due to the requirement to align products from different operators, and to have proper network representations of all the grids involved, transmission and distribution, with the need of those to be potentially shared with an independent (IMO) (or a TSO-DSO coordination platform, as introduced in [18]). In addition, as a common market requires a complete harmonisation of products, product requirements can be challenging to meet for small-scale resources, constituting barriers to their participation, which in turn can reduce the efficiency of the common market as has been investigated in the H2020 OneNet project [16], [52]. Indeed, the OneNet project [16] has investigated the entry barriers that product requirements can introduce and how these can vary in different TSO-DSO coordinated market models. The creation of a local market layer, e.g., as part of a sequential market scheme combining a local LFM followed by a central TSO-level market, which in turn is also open for the participation of distributed flexibility, can contribute to decreasing entry barriers for small-scale resources, as such local markets can, by design, be tailored not only towards the local needs of the grid but also the technical needs of the available flexibility resources. However, as also shown in [16], even though this process can improve market participation by enabling local flexibility resources to participate, which otherwise may have been prevented from participation in centralised common market schemes, which induces efficiency gains, it, on the other hand, leads to market fragmentation as compared to the common market, thus leading to efficiency losses due to the loss in value stacking potential. As such, the general impact of the addition of local market layers in sequential market settings on the market efficiency can be case dependent, and this trade-off between efficiency-improving market participation and efficiency-decreasing market fragmentation has to be considered when deciding on which TSO-DSO coordination scheme to implement.

Insights from the surveyed LFMs

Most LFMs currently operate as separate DSO market but show growing interest in increased TSO-DSO coordination, with some initiatives aligning their timing with wholesale and balancing market processes.

As shown in Figure 2-32, today, most of the surveyed LFM initiatives have established a separate DSO LFM. This setup implies limited coordination between the TSO and DSO, with the DSO acting as the sole buyer in the market. Several of the surveyed LFM initiatives have explained that this approach is primarily due to the limited scale and maturity of current LFMs. These initiatives are still in the process of understanding how the procurement of local services functions, which means that simplifying the LFM design is essential, especially since maximising flexibility remains their top priority.

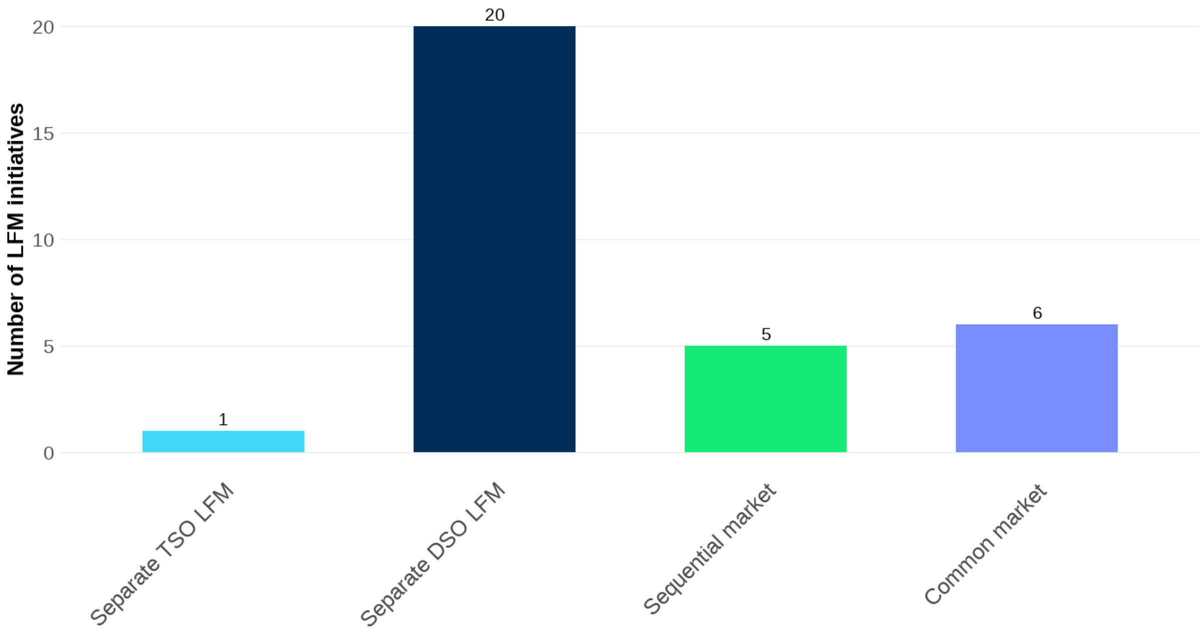


*Figure 2-32: TSO-DSO market models implemented in the surveyed LFM initiatives (Source: VITO own figure).*

However, despite this, most initiatives indicate that they do, or are starting to, coordinate with the TSO. Some initiatives pointed out that, even though TSO-DSO coordination is out of scope today, there are ongoing developments and **discussions** around coordination and integration with the TSO. Other initiatives go further by already automatically **sharing** market participation results between DSOs and TSOs. In the UK, there is for instance a MW Dispatch programme that allows DSOs to oversee and veto TSO actions when UKPN aims to procure flexibility in the opposite direction [107]. Furthermore, TSO-DSO interactions do occur more frequently in terms of accounting for each other's **grid constraints**. For instance, by allowing the DSO to put limitations on DSO-connected resources that plan to contribute to TSO-markets.

Therefore, there is a clear progress towards increased TSO-DSO coordination. The outcome of the SO-workshop also indicated that in the future, quite some initiatives believe sequential markets with automated bid forwarding and common markets are most appropriate for the procurement of local services (see Figure 2-33). In the short run, it is however, still probable that intermediate steps such as sequential markets without automatic bid forwarding are most plausible. The topic of automatic bid forwarding will be discussed in more detail below.

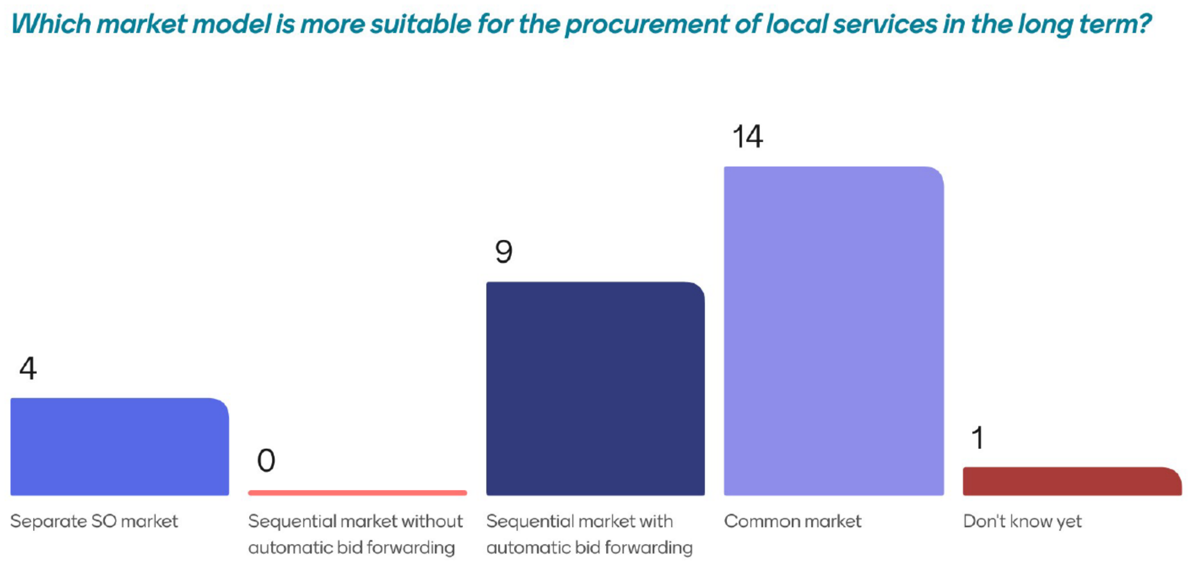


Figure 2-33: Poll results on preferred LT market models for the procurement of local services during the SO workshop (Source: own figure).

In Figure 2-32, we see that even today, 27% of the surveyed initiatives are already implementing sequential or common markets.

For instance, five initiatives implement **sequential DSO-TSO markets**, where the DSO procures flexibility before the TSO market opens (e.g. Spanish regulatory sandbox, Sthlmflex, Euroflex, FinFlex, E.ON Energy Networks Sweden). TSOs acknowledge that activating bids that negatively impact the DSO grid benefits neither party. Both SOs face challenges when the DSO grid is congested, as the TSO cannot access the required flexibility either. Therefore, resolving grid congestion should take priority over balancing. If the DSO grid is not functioning properly, balancing cannot be performed efficiently or effectively. However, the survey also identified an initiative where the TSO was given priority over the DSO, requiring the DSO to delay market clearing until the results of the TSO's daily balancing capacity tender were available. Nevertheless, in most cases, local needs are prioritised over higher-level flexibility requirements.

The six initiatives that focused on **common markets**, mostly focused on common congestion markets (SF2.0, OneNet Northern Demonstration Finland, Flex.on LFM, GOPACS, Opentunity Greek demo, TDC LFM Switzerland). It was pointed out that setting up a common market requires similarity in SO needs, which is less the case between balancing and congestion products as balancing does not have the geographical requirements. Generally, it was highlighted frequently that requirements for established ancillary services at the TSO level are more complex. Furthermore, some requirements for TSO markets are not the same as for the DSO markets. Nevertheless, two initiatives in preparation are considering setting up a common market for both congestion and balancing services.

**Bid forwarding**

In a sequential DSO-TSO market (or an LFM and wholesale energy markets), unused flexibility bids submitted to one market can be forwarded to the next one, either manually by the FSPs or automatically. This process is called bid forwarding. (Automatic) bid forwarding can enhance value-stacking potential and reduce transaction fees for FSPs. Meanwhile, for SOs, the increased participation can potentially reduce the cost of procurement. Automatic bid forwarding requires a processing layer between the two markets to make sure that: (i) the market requirements of the subsequent market is met, and (ii) the flexibility forwarded when cleared in the subsequent market is safe for the grid to which the flexibility resources are connected [16], [108]. This mechanism is captured in Figure 2-34.

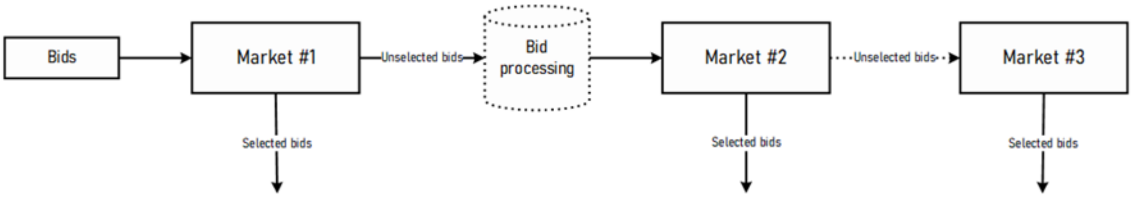


*Figure 2-34: Bid forwarding process [16]*

Forwarding bids requires product compatibility, i.e., the product requirements of the markets in which an FSP participates can be simultaneously satisfied, which requires the markets to have a harmonised set of product attributes, or requires that the next market's requirement (i.e., the destination of bid forwarding) must be at most as stringent as the preceding one (the source of the bids to be forwarded) [16], [108]. The H2020 Onenet project [16] has investigated the different set of product technical requirements and processing steps which are necessary to enable bid forwarding [16], [108]. Such requirements also apply for bid requirements, wherein, the bids considered for bid forwarding should be of types and characteristics abiding by the destination market (which can require some bid manipulation in the processing stage to enable the forwarding of those bids), as investigated in [16], [18]. Some challenges facing bid forwarding in general, or preventing some flexibility bids from being forwarded or some flexible technologies from engaging in bid forwarding in particular, include: technology-specific entry barriers (preventing technologies from participating in the destination market), aggregation requirements (preventing aggregated technologies from participating in the destination markets), bid requirements – such as minimum bid size and bid quantity granularity requirements – preventing unused bids from being forwarded, reservation requirements and disallowing participation of free bids - energy bids that do not participate in a capacity market – preventing flexibility bids from being forwarded as they are not associated to a reserved capacity, as well as differing PQ requirements between the markets. An extensive analysis of bid forwarding in flexibility markets can be found in [16].

One key element in forwarding bids (e.g., from distribution-level markets to a transmission-level market) is ensuring grid-safe activation of these bids, as the destination market does not normally take into account a network representation of the grids involved in the source market, risking causing congestions or other network issues in grids to which the flexibility is connected. To mitigate this issue, an ex-ante and/or an ex-post process, i.e., ex-ante grid PQ or an ex-post corrective step, can be included in the market scheme, as studied in [23] and [102]. Grid PQ (see Section 2.2.3.1), especially performed dynamically, filters out bids or limits the bid quantities so that only the set of bids that can be safely activated is forwarded. On the other hand, an ex-post corrective market scheme is an extra local market layer needed to resolve any network issues caused by the activation of distribution-level bids by the transmission-level market.

Finally, a party responsible for bid forwarding should be appointed, which may not be straightforward. For example, in the NorFlex project, a pilot on bid forwarding, a third-party local MO was assigned to aggregate the remaining bids of its local market and acted as a BSP in the balancing markets and undertook the associated responsibilities [16].

<u>Insights from the surveyed LFMs</u>
Bid forwarding is not yet widely applied in LFMs, as current focus lies on gaining experience and building market maturity. While seen as a way to improve liquidity, enable value stacking, and support market coordination, it also raises concerns about roles, technical complexity, and compatibility across markets.

Today, among the surveyed LFMs, it is evident that automated bid forwarding is not implemented in most initiatives. Only four of the surveyed LFMs have implemented bid forwarding (e.g. Finnish OneNet Demo, Euroflex and Sthlmflex) or are planning to implement it (as the LFM is currently still in preparation (e.g. Swiss TDC LFM). However, during the SO workshop, it was emphasised that this only reflects the current status of the LFMs, which are mostly immature, still in the piloting phase, and aiming to build up experience. With increasing levels of market maturity, bid forwarding considerations will also be taken up. Today, there are already initiatives that use platforms that have built-in functionalities to allow bid forwarding, and they are open to test it if it would further improve market liquidity and if the TSO is interested. Nevertheless, it is also pointed out that bid forwarding is only relevant in ST markets. From the workshop discussions and survey responses, several arguments both for and against bid forwarding emerged. These are summarised in the table below.

The NorFlex LFM pilot (now continued as EuroFlex) provided key insights into bid forwarding. In this project, NODES acted as a BSP in Statnett's mFRR market, aggregating unmatched ShortFlex bids after the local market gate closure (two hours before delivery) into a single hourly order priced at the highest individual bid. NODES submitted these aggregated bids under its own name, with settlement handled through eSett's imbalance process. Although aggregated prices were often too high for activation, the forwarded volumes represented up to 5–6% of total mFRR offers in NO1, demonstrating potential value during grid constraints. The pilot also revealed the need for improved pricing and better integration between market and SOs to ensure transparent settlement.

While bid forwarding presents potential benefits for LFMs, most surveyed initiatives regard it as a lower priority, given that they are still in the process of gaining experience. Furthermore, in the medium term, some conditions still need to be put in place before bid forwarding is indeed feasible in practice.

*Table 2-2: Arguments in favour of / against bid forwarding, as provided during the workshops and by the surveyed LFM initiatives.*

| Arguments in favour of bid forwarding | Arguments against bid forwarding |
| --- | --- |
| - **Improved liquidity in LFMs** – LFMs often suffer from low liquidity; automatic bid forwarding can help increase the pool of buyers and sellers.<br><br>- **Positive real-world implementation** – In Norway, bid forwarding was implemented in the past NorFlex project and considered effective and beneficial by smaller FSPs.<br><br>- **Technical feasibility** – Most platforms are technically capable of implementing automated bid forwarding if the SO wants to apply it and the FSP desires it.<br><br>- **Supports market coordination** – Bid forwarding is seen as a form of coordination between markets, potentially avoiding siloed operations and encouraging broader participation.<br><br>- **Value stacking** – Small FSPs benefit from bid forwarding as it allows them to be active in several markets simultaneously. Forwarding bids can be part of a broader strategy where FSPs earn revenues from multiple services/markets.<br><br>- **Voluntary** - Bid forwarding can perfectly be done on a voluntary basis. It should not be mandatory, FSPs can choose whether they want their bids to be forwarded. This adds flexibility without imposing rules. | - **Markets have distinct designs and purposes** – Products and pricing structures differ; a bid appropriate in one market may not make sense in another.<br><br>- **Implementation complexity** – Forwarding an entire bid across markets introduces significant technical and practical challenges, including bid type incompatibility[12]. It is also claimed to be IT cumbersome and expensive.<br><br>- **Bid forwarding may miss the bigger picture** - Market coordination should focus on broader system-level integration, not just on bid forwarding mechanisms. The focus should be more on ensuring services can be sold across all relevant markets.<br><br>- **Need for innovation space** –While bid forwarding could support value stacking, its design should remain flexible to avoid constraining innovative market solutions. Additional experimentation with different modalities, including both manual and automatic bid forwarding, could help identify the most effective approaches.<br><br>- **Roles and responsibilities –** There is some uncertainty regarding which actor should be responsible for forwarding bids to other markets, whether it be the MO, a neutral third party, or, as suggested by some, the FSP. |

### DSO-DSO coordination

In addition to TSO-DSO coordination, **DSO-DSO coordination** should also be considered in the context of LFMs. DSOs must coordinate effectively when multiple DSOs operate within interconnected grid areas or share grid infrastructure (e.g., in meshed networks). This coordination is essential to 1) **optimise grid operation** by ensuring grid stability, preventing conflicting flexibility activations, and optimising local flexibility resources across different distribution networks and 2) **supporting market access for FSPs** by having

[12] Many bids in existing markets are portfolio-based and lack precise locational information, making forwarding of these bids for local needs (e.g., congestion) difficult.

similar governance rules, product requirements and operational processes. DSOs can coordinate in various ways, such as: alignment on the design of the market; common processes and procedures for flexibility procurement, activation and settlement; real-time data sharing to improve transparency and visibility; standardising flexibility products and market mechanisms to ensure consistency across DSOs; establishing common or coordinated procurement mechanisms to streamline flexibility acquisition. The topic of DSO-DSO coordination has not been widely documented in the literature, but the analysis here will examine to what extent LFM initiatives have addressed it.

<u>Insights from the surveyed LFMs</u>
Today, DSO-DSO coordination during procurement in the context of LFMs is not yet very frequent, and in most cases, LFMs are set up independently while testing their own solutions. However, DSO-DSO coordination is expected to increase as markets mature, with the need for further harmonisation and coordination naturally emerging.

In the surveyed LFMs, DSO–DSO coordination during procurement appears to be infrequent. In Sweden, 3 DSOs are using the same market platform to procure flexibility or activate FCAs. Furthermore, there are agreements between local and regional DSOs, ensuring that local DSOs have flexibility procurement priority[13]. Collaboration with DSOs in Sweden that are not directly connected to each other's grids, takes the shape of knowledge sharing, engagement strategies, and work on standardisation and harmonisation of market and product design. In countries where there is no overlap in operated regions, LFMs are set up independently and are testing their own solutions. However, there are some countries where DSO coordination is taken to the next level. In the UK, the Energy Network Association (ENA) gathers all British DSOs to ensure operational standardisation across all LFMs. The Open Networks project ensured alignment on flexibility products, market design, API specifications and other market aspects. Finally, there are countries such as Spain, in which a standardised market design is set up in collaboration with many DSOs as part of a regulatory sandbox.

**Coordinated market design**

Coordination market design entails the alignment of market design elements or certain processes with other markets. As a result, alignment can occur across all elements of the classification structure, including product design, market design, and governance. Many aspects of coordinated market design have already been described in the previous sections. The following provides a brief overview, with references to earlier sections for more detailed discussion.

<u>Insights from the surveyed LFMs</u>
While most LFMs currently focus on their own development and limit coordination to reduce complexity, many recognise the LT value of harmonisation. Coordination efforts vary - from aligning products, market timings, and market processes (like PQ, settlement) to integrating with other flexibility mechanisms like FCAs - reflecting a gradual move towards more cost-efficient, standardised, and interoperable market designs.

Most LFMs today prioritise their own development and avoid overly complex designs, which means coordination efforts remain limited at this stage. However, only a few initiatives see no need for coordinated market design - typically those that operate as the sole flexibility market in their country or cover the entire national territory. The majority of initiatives recognise the value of coordination and pursue it in various ways: some seek alignment with other markets, including wholesale markets, to simplify participation, while others

[13] In Sweden, some DSOs operate regional flexibility markets, while others have local flexibility markets within the regional flexibility market to handle local congestion limitations. This means that FSPs assets are available for both markets. It is agreed that local problems receive priority and that the LFM local flexibility markets has an earlier activation time to allow for this.

focus on aligning specific processes such as PQ. For less mature LFMs, any degree of alignment is seen as a positive step towards more cost-efficient and harmonised markets. A short overview with references to relevant sections is provided below:

- **Coordinated and harmonised products**: As discussed in section 2.2.2, Across the surveyed initiatives, views on harmonisation differ. Some see the use of existing commercial platforms and their products as a form of implicit alignment, while others adapt products from other LFMs or countries with minimal modifications for local needs. A few countries (such as UK, Sweden and Spain (regulatory sandbox) go further by focusing on product harmonisation on country level. In most cases, harmonisation efforts focus on product alignment and coordination between DSOs. Alignment with wholesale or balancing markets is rare, as local flexibility needs often differ and require less strict product definitions.
- **Coordinated and aligned market timings**: As discussed in section 2.2.3.2, Several LFM initiatives aim to coordinate and align their market timings with national wholesale and balancing markets to support value stacking, simplify participation, and avoid double activations. Synchronised trading windows, such as 4-hour slots similar to balancing markets, help FSPs deploy assets across multiple services and facilitate SO coordination. However, this alignment does not always match DSO needs; Some initiatives noted that day-ahead scheduling can leave too much lead time, limiting access to last-minute flexibility. International coordination is also emerging, as seen in the collaboration between Baltic DSOs on shared processes and joint flexibility platforms.
- **Alignment of market phases beyond trading**: Alignment of market phases beyond trading - such as PQ (see section 2.2.3.1), baselining and settlement (see section 2.2.3.4) - is emerging in some countries (e.g. UK, Sweden, Spain regulatory sandbox). Furthermore, in the UK, the idea of a common flexibility register is being explored to further streamline participation. Also in Italy, despite not having a standard product yet, DSOs which are involved in pilot projects have coordinated on settlement processes and on PQ requirements. GME has standardized the processes and the communication related to the platform use, ensuring that all DSOs that want to join the LFM, can easily do so.
- **TSO-DSO coordination**: as discussed in section 2.3.1, 11 of the surveyed LFMs strive for sequential or even common markets, increasing coordination between DSO and TSO markets. Nevertheless, most of the surveyed LFMs are currently operated as separate DSO-led markets.
- **Alignment supporting processes**: To achieve aligned and coordinated markets, developments in data sharing, common IT infrastructure and platforms, and linked processes are essential. In some countries, such as Sweden, DSOs are collaborating on methodologies for valuing flexibility and assessing flexibility needs. This was also highlighted during the SO workshop, where stakeholders stressed that transparent and fair markets require clarity on how the value of flexibility is determined. Several LFM initiatives are advancing coordination through practical measures: some harmonise data exchange formats, to support bid reuse across markets and simplify participation in services like redispatch and balancing. Some UK initiatives plan to adopt standardised dispatch formats based on OpenADR 3.0 from 2025, improving consistency and interoperability across platforms and markets. Automated interfaces and APIs are becoming more common, enabling fully automated trading cycles and easier FSP access across markets with similar interfaces. In some countries with multiple aligned LFMs, such as the UK and Italy, there is growing interest in common platforms to reduce complexity for FSPs - though in Italy, DSOs retain the freedom to choose their platform, resulting in varying solutions.

Finally, quite some initiatives also highlight **coordination with other, potentially non-market-based mechanisms**. When discussing with the surveyed LFMs, most of the discussions were centralised along the trade-off with non-firm / flexible connection agreements. Coordination of LFMs with tariffs was often not considered as tariffs are in most cases not dynamic (yet). In addition, grid tariffs were generally seen as complementary to LFMs, as they provide generic signals but are not the most appropriate mechanism for addressing highly localized issues. The following elements were highlighted:

- In quite some initiatives, no trade-off was considered between other flexibility mechanisms, simply because FCAs or more dynamic grid tariffs were, for instance, not in place in a specific country. However, there are also initiatives that are simply testing LFMs to gain experience and to see how it works, independent of other mechanisms. As such, the SOs can verify whether market-based flexibility is a viable solution, as such collecting data to do a proper trade-off with other mechanisms afterwards.

- Some LFMs see FCAs as a parallel solution which they particularly have in place, to manage very large generation connections.

- In some countries, there are already national procurement rules which are already determining which flexibility solutions should receive priority. In certain countries, market-based solutions should receive priority (e.g. Sweden), in other countries (e.g. Hungary) the DSO network code states that flexibility from FCA should be prioritised above market-based flexibility.

- Among the surveyed LFMs, there are also initiatives that ensure FCAs can join the regular LFM. The UKPN LFM initiatives for instance, does not prevent consumers with a FCA to join the market. Some more advanced market platforms directly integrate the LFMs and FCAs in the same platform (e.g. E.ON Energy Networks Sweden, Flex.ON Hungary). When there are forecasted peaks, they will do a trade-off between the different options or apply certain priority rules (see previous bullet). One initiative (Elektro Primorska LFM) also considered FCA in their LFM by submitting bids through connection agreements at the highest price, as such making it a last resort solution. The Dutch LFM GOPACS was initially developed to manage congestion via market-based redispatch and was later complemented by regulated FCAs, which help streamline processes and communication.

- Finally, there are two initiatives in preparation in which grid users with a FCA can join a flexibility market to trade their curtailment obligations with other grid users who are on non-curtailable/ firm connection agreements, through a P2P trading platform (BiTraDER and the ORES SCOPE initiatives). This enables grid users with FCA to avoid or reduce their risk of being curtailed.

### *2.3.2 Information sharing*

In this part of the classification structure, we will focus on the level of **information sharing** at several time instances, i.e., before the market opening and before and after the actual procurement. Effective information sharing in LFMs is important to incentivise market participation, ensure market transparency, and create fair competition among participants. It enables FSPs and other stakeholders to make informed decisions. A distinction is made between public information and restricted information.

<u>Insights from the surveyed LFMs</u>
It should be emphasised that there are many differences between the surveyed LFMs in terms of the type and level of information sharing. Although today most LFMs already provide information on market rules and market events, information on flexibility needs, value, and availability is more limited and differs largely between LFMs. However, there is a clear tendency towards increasing information sharing to support transparency and fair competition.

The level and type of information shared within LFMs varies significantly across the surveyed initiatives. The types of information shared can be discussed along two dimensions: *what* information is shared and *when* it is shared. Figure 2-35 summarises the different types of information that are shared by the surveyed LFM initiatives at several moments, i.e. prior to the market opening, prior to the actual procurement, and after procurement. This information is primarily shared through websites, dashboards, market platforms, and reports from the DSO or MO.


Figure 2-35: Type of information shared in the surveyed LFMs at different time instances (Source: VITO own figure).

The type of information shared by the surveyed LFM initiatives has been categorized into five groups: information on market rules, announcements of market openings, amount of flexibility needed, the value of this flexibility, and the availability of this flexibility.

First of all, almost all of the surveyed LFM initiatives share information on the **Market rules**. This includes the market design, market procedures, product definitions, and rules that govern participation (e.g. evaluation criteria, contracts). Generally, these are all defined in tender / market regulations. In highly transparent initiatives, this also includes how bids are evaluated, as well as clearly defined rights and responsibilities for all actors. The latter may include information on e.g. penalties that could be in place when FSPs fail to deliver the promised service. Furthermore, some LFMs work with standard contracts and/or templates to give all participants an equal footing from the start. Except for pilots or very limited markets, it is generally seen and agreed that market rules are shared ahead of procurement, even **prior to the market opening**. Providing the rules publicly before market opening enables potential FSPs to better understand the requirements and prepare for participation. Only in early-stage markets or markets in preparation, the survey results show that there might be less transparency as only the directly involved partners are aware of the basic terms and conditions. Generally, these initiatives only make sure involved participants and partners are informed and are not yet considering informing a broader audience. During the SO-workshop, in line with discussions on market neutrality linked to the role of the (independent) MO (see section 2.3.3), it was highlighted that clear, transparent and non-discriminatory rules are indispensable and should be communicated ahead of market opening.

Secondly, effective information sharing also involves **announcing market events** in a timely, public manner. Market announcements generally include general announcements or notices about upcoming market opportunities, procurement rounds, or tenders. This can include detailed timings for market deadlines, such as registration timing, market opening, and so on. High-transparent LFM initiatives maintain regular announcements for upcoming procurement opportunities. For instance, some DSOs publish an annual or periodic procurement schedule or prospectus that outlines when and where they plan to seek flexibility services. In doing so, some of the LFM initiatives allow FSPs to pre-register in the market, allowing them to inform registered participants in a targeted manner via email alerts. However, some LFMs that only apply a more minimalistic information sharing approach, might even only inform pre-registered FSPs, which is less in the spirit of providing equal and timely communication to all potential providers. Yet, in pilots, the target audience if often more limited, justifying this approach. Regardless of how public the market announcement is, it is clear that such announcements always occur **before the market opening**. The earlier this information is shared, the more time FSPs have to assess the opportunity and make the necessary preparations.

Thirdly, **flexibility need information** might be **shared at multiple time stages**: that is prior to market opening, prior to procurement and also after procurement. Flexibility need information includes details on DSO's required flexibility – typically the location (area of the grid), timing (when flexibility is needed), and quantity (MW or MWh) of flexibility sought. The surveyed LFMs show a high variability in how they share their flexibility needs and requests. In addition, the level of detail and/or granularity of this information depends on the timing of information sharing. Prior to market opening, when information is shared, this is more likely to be done with less level of detail, for instance through congestion (heat) maps and within network development plans. In this way, DSOs aim to signal their needs in a broader way, defining relatively large geographical zones. As such, ahead of procurement, SOs aim to be transparent through broader need announcements, inviting more providers to offer solutions, as long as they are located within that area, without revealing exactly which grid element is the bottleneck. **Closer to procurement**, SOs are more likely to provide more detailed information on flexibility requirements (e.g. size, timing and direction of the needs), or they share updates on flexibility needs through the market platform. Some initiatives also give indications on the activation probability. In this way, SOs confirm their exact needs. **After market procurement**, initiatives sometimes publish information on the volume of offered and accepted bids. This can be in a detailed manner or based on aggregated statistics. Some DSOs also share ex-post their total requested flexibility demand.

The surveys revealed a broad variation in LFM approaches regarding the willingness to share information on flexibility needs. Some of the surveyed LFM initiatives share detailed information on flexibility needs, while others provide it in more aggregated forms. Indeed, there is a recognised tension: SOs worry that sharing extremely granular or precise constraint information publicly could enable gaming (participants might exploit knowledge of a critical constraint by raising prices), while in contrast, information sharing is also deemed necessary for efficiently functioning of LFMs. In the surveyed LFMs, many SOs choose to publish only the essential details, sufficient to invite offers but not detailed enough to disclose all grid vulnerabilities. Furthermore, especially in starting-up LFMs, it was indicated that due to the immature status of the market, they were still running in preparation or piloting-modus, explaining why they only shared the minimum information needed for testing purposes or only with involved partners. Pilots in preparation, pilots that run for a temporary period or for a limited testing area, are sometimes more likely to only share information that is required to cooperate with different partners. Additional data sharing for more optimal market functioning, in that case, does not receive the primary focus. A final key argument of not sharing detailed information on flexibility needs was linked to this information not being available at the time the market would like to receive the flexibility bids. This can occur in markets where the market closes before the results of the day-ahead congestion forecasts and network calculations are published. Apart from the timing of flexibility calculations, more generally, to announce flexibility needs in advance, a DSO must have tools to predict where and when its network will face issues. In some cases, DSOs are still developing these analytical capabilities. If a DSO is not confident in its forecast (perhaps they lack sensors or accurate models at the distribution level), they might be hesitant to publish detailed needs that could later change. In the workshop, this was referred to as a "chicken-and-egg problem" because SOs sometimes require flexibility bids before network calculations are done, while at the same time, FSPs cannot be expected to place bids without guidance.

Despite the previous arguments, in the SO-workshop, 90% of the answering SOs clearly indicated that they were willing to share flexibility need information prior to procurement. This is more than we generally registered in the surveyed LFM initiatives responses where initiatives were merely indicating how they are currently handling information sharing. From the SO-workshop, it became evident that, while not all of them are ready today, they deem information sharing with FSPs on their needs indispensable to increase market liquidity. Furthermore, sharing need information would increase market transparency and trust. This is because, when more limited information is shared (e.g. if needs are kept very broad or secret), providers cannot easily respond or assess that there is a real opportunity. It was also noted that need information should be shared in due time, as last-minute or missing disclosures from the DSO limit FSPs' ability to participate. Finally, it is worth noting that in some countries (for instance Lithuania), information sharing requirements are already defined in national laws, stating which information at which level of detail needs to be shared. In summary, there is a clear trade-off between required informational details and strategic withholding, influenced by the maturity of the market and the level of information that is available at different moments in time, which is affecting how needs are communicated.

A fourth category of information is linked to the **value of flexibility**. This includes information about the pricing of flexibility, such as bidding price limits, information on maximum willingness-to-pay, and the market outcome (cleared prices). Few surveyed initiatives use fully visible open order books, allowing all participants to view each other's submitted orders. However, from the discussions in both the surveys and the SO-workshop, it became clear that only one third of the SOs was willing to offer some form of price indication with FSPs, making this topic more controversial than the topic on the flexibility need. A key concern was that, by publishing e.g. bidding price limits, FSPs would be incentivised to submit bids close to these limits. It was argued that SOs should avoid influencing market behaviour and functioning by disclosing this information too early. The discussion on whether or not to share information in LFMs, is therefore highly dominated by the timing of sharing of this information (before or after procurement). Yet, at the same time, this is also influenced by the type of pricing mechanism applied. In case pay-as-cleared mechanisms are used, price information is automatically shared after the clearing. However, LFMs are more likely to use pay-as-bid mechanisms. Furthermore, the timing of sharing information is also influenced by the procurement timing. In case of e.g. LT ahead procurement, maximum reservation prices are more likely to be communicated in some cases, indicating towards FSPs that if they go beyond these maxima, SOs will proceed with grid investments. This adds to the discussion the challenge of finding an appropriate and transparent methodology on how to determine those maximum prices. They survey showed that some SOs do determine a maximum price they are willing to pay for flexibility, which they do not share outside their organisation. However, some initiatives do recognize that sharing the methodology to calculate this price, raises trust and confidence in the market. Finally, another key criteria that influences the discussion was market liquidity, claiming that given the localised and low-liquid LFMs, sharing too much information could lead to higher flexibility procurement costs. On the other hand, initiatives that did share price information, do so, to inform inexperienced FSPs on the pricing level, with the aim to increase the level of flexibility offered to the market.

A final category of information is linked to **flexibility availability**. This includes information on the availability of flexible resources and the outcome of procurement – for example, which volumes were contracted (reserved) and how much was activated or delivered during events, compared to the offered flexibility. From an FSP perspective, knowing how many competitors are in the same area can influence their strategy (and too much transparency here could even facilitate collusion, as competitors know each other's presence). Thus, most markets simply ensure that all who want to register can do so, but they do not openly list all participants (aside from perhaps naming accepted FSPs after contracts are awarded).

### *2.3.3 Roles and responsibilities*

Different activities can be distinguished in setting up and operating an LFM. These activities range from operating the flexibility register, performing PQ, and defining grid needs, to procuring flexibility, validating flexibility delivery, and settlement. Traditional roles of IMOs include market clearing, communication of market results, platform operation and provision, and market settlement [66]. Figure 2-36 extends these roles to the different relevant market phases discussed before. Certain activities typically associated with market operation, such as effective matching of bids and orders, and the final selection of bids are, in some cases within LFMs, carried out by the procuring SO, even when an independent IMO is present [17]. In the classification structure in annex 1 the roles and activities have been defined more in detail. These activities are also discussed in literature [17], [66], [109].

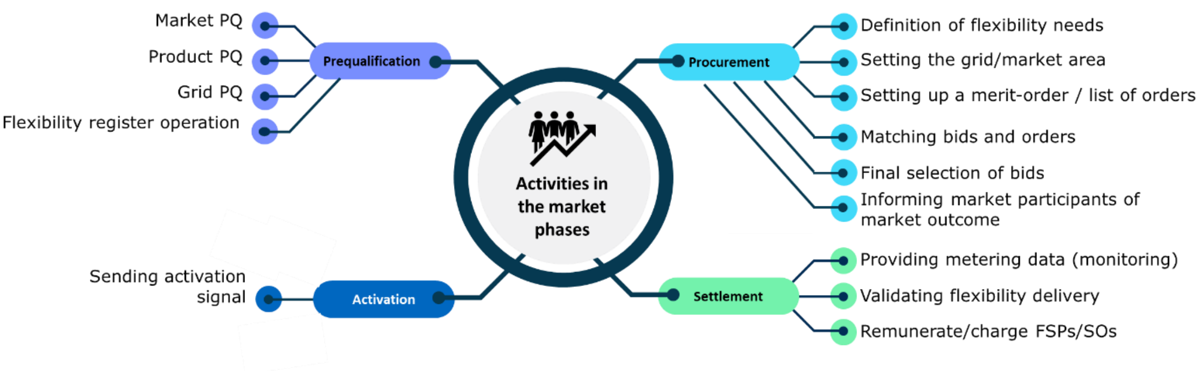


*Figure 2-36: Activities in the different market phases of LFMs (source: VITO own figure)*

As mentioned, in LFMs, the role of the MO can be taken up by an SO or by a third party / IMO. There is quite some scientific controversy related to the question on who should take up the role of the MO [110]. In this regard, there is a tension between whether these roles should be taken up by regulated or commercial actors. BOX 7 zooms in on benefits and disadvantages of having an IMO based on literature.

BOX 7: Benefits and disadvantages of the independent MO

**Benefits** of more independent, third parties, indicated in related literature [110], [111], [112], [113], [114], [115], [116], [117] are for instance: improved neutrality and reduced conflicts of interest; improved transparency in bid matching; improved communication and coordination between market players; increased possibility of having multiple TSOs and DSOs as buyers; increased competition and easier access for customers; improved interoperability with other market platforms; improved data security and encryption possibilities due to the knowledge of the MO. Having an independent MO is also deemed beneficial in areas where there are multiple DSO interconnections and in areas where SOs do not yet have the capabilities and/or are not allowed to run such a market. In addition, it is argued by [118] that DSOs have 'no or little experience operating a marketplace to procure grid services'. Previous research projects, however, also highlight some **disadvantages** of having an IMO. A third-party flexibility MO implies that an additional actor is involved leading to higher coordination efforts and adding a layer of complexity and cost to an already complex environment. Furthermore, there is a need for interface management between the DSO and the local MO. Efficient data sharing between the IMO and the SO is thus important to ensure that the IMO can operate the market in the most efficient and effective way. Moreover, data sharing is often challenging, requiring enhanced data security and GDPR complexity. Additionally, another complicating factor is linked to the fact that it is not yet fully defined and agreed upon which activities in LFMs will be performed by the IMO and/or other parties [119]. Finally, SOs must optimise various flexibility mechanisms- both market-based and internal - which is facilitated when they operate and can coordinate all mechanisms themselves [66].

In theory, there should be a strict separation between different market roles, implying that a role is described as a unique combination of responsibilities and activities that cannot be shared between different actors [117]. However, the role of the DSO is shifting from passive to active grid management. It is the DSO's responsibility to ensure that procured flexibility resolves grid constraints and safeguards network security. The contribution of each flexibility offer to meeting DSO needs must be clear, and grid constraints must be reflected in market clearing [121]. From a system efficiency perspective, the DSO should always seek the most cost-effective solution, starting with zero-cost options such as grid reconfiguration [122]. DSOs can address congestion through various mechanisms: grid reconfiguration, network reinforcement, dynamic network tariffs, flexible connection agreements, or flexibility procurement. These options should be assessed jointly to minimise total system costs, with combinations considered where appropriate [122], [123], [124]. As these data are not always accessible by third-party MOs, previous research projects have shown that a strict separation of the different roles and activities has proven to be not always easy to achieve in practice [17], [109]. In particular, activities in the procurement phase (especially the bid selection phase), are highly debated for reasons described in this paragraph (SO responsibility, evaluation market-based flexibility with other mechanisms, data availability).

<u>Insights from the surveyed LFMs</u>
Most surveyed LFMs outsource platform operation to independent providers, while SOs remain key in defining flexibility needs and ensuring grid security. It is argued that neutrality and trust depend on transparent processes, clear roles, and harmonised rules to manage both single-buyer and emerging multi-buyer setups. In this sense, there is room for new roles, to tackle new challenges.

As previously discussed in Figure 2-8, in most cases, the surveyed LFMs are operated by a commercial platform provider. In Figure 2-37, for all the surveyed initiatives, it is visualised which actor is responsible for the different activities identified in Figure 2-36. When looking at "All Initiatives" together, a number of general conclusions can be drawn. First of all, as mentioned before and also illustrated in Figure 2-37, most initiatives, about two-thirds of the surveyed LFM initiatives outsource platform provision and operation to an independent third party. Secondly, all activities linked to evaluating flexibility needs (e.g. defining flexibility needs and market areas) and performing market, FSP and grid PQ, mostly is the responsibility of the SO. Thirdly, activities linked to metering and validation, are also more likely to be taken up by the SO. Finally, it should be noted that there are also quite some LFMs which are still deciding on which actor should eventually take up a certain role. This is often the case with immature LFMs, LFMs which are still in preparation or pilots that are simply being run for a temporary period or for testing purposes.

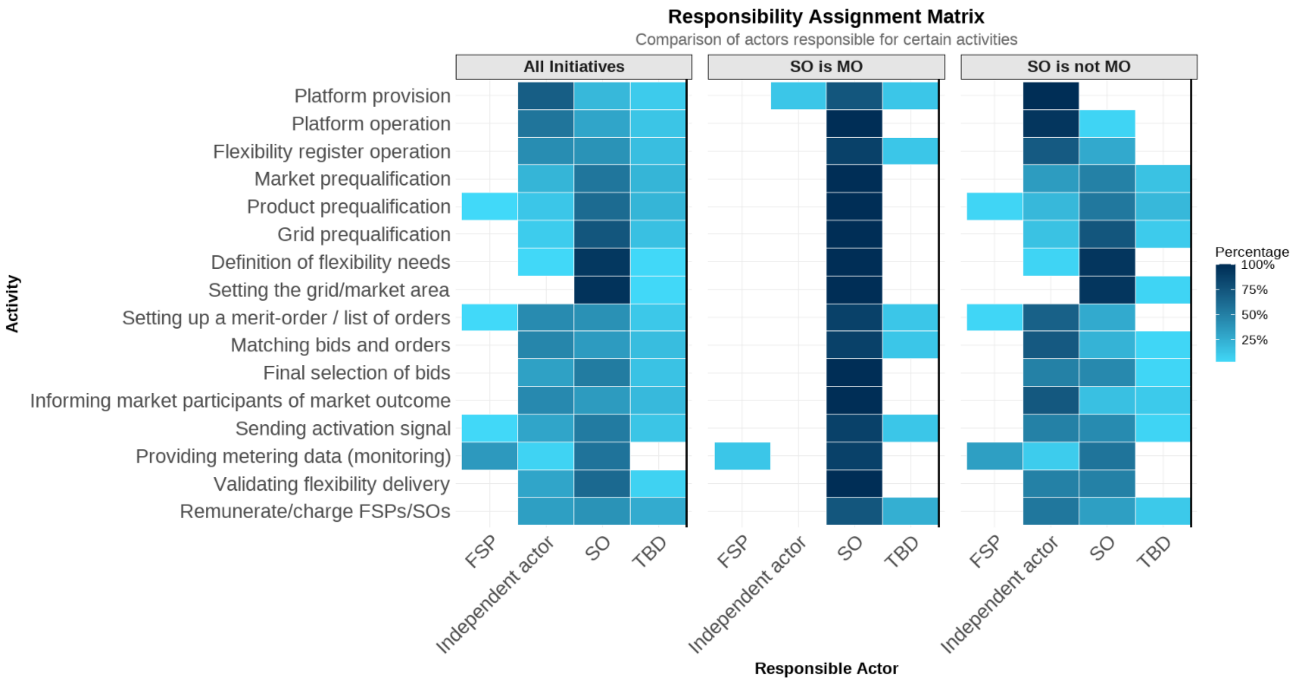


Figure 2-37: Overview of responsibilities for different activities in surveyed LFM initiatives (Source: VITO own figure)

However, looking at activities in the procurement phase, more specifically those linked to bids and order matching and the final bid selection, it is necessary to take along the discussion on who takes up the role of the MO. In this respect, we see a clear difference between the eight initiatives where the SO takes up the role of the MO, and between the other initiatives where the MO is not the SO (but an independent third party). When the SO also assumes the role of MO, the majority of activities are naturally undertaken by the SO. However, in certain cases, the SO may engage third-party providers to support the development of in-house platforms. However, when an independent third party serves as the MO, procurement activities in particular are typically handled by this independent actor, except for the final bid selection activity, in which the SO is involved in a bit more than half of the initiatives (see also discussion in section 2.2.3.2).

In the workshops, it was therefore argued that it is essential to consider how the choice of MO shapes the different activities. The operator's role not only influences who performs specific tasks, but also affects perceptions of neutrality, transparency, and accountability. Independent MOs highlight the potential for conflicts of interest if SOs operate or own market platforms. They argue that independent operation can enhance neutrality and competition, provided that governance frameworks are robust. On the other hand, SOs argued that, as the party responsible for grid security and the single buyer in flexibility markets, they are uniquely positioned to ensure reliable and secure operation. In some cases, current public procurement obligations further constrain how SOs can delegate procurement tasks. Additionally, SOs caution that outsourcing market operation could risk market concentration and increase LT switching costs.

The study further highlights that LFMs are evolving to accommodate more complex configurations, including new roles to support coordinated operation. In the Greek Opentunity Demonstrator, for instance, a **market coordinator role** has been introduced to oversee activities within a shared market space involving multiple buyers - a notable departure from the conventional setup where a single buyer procures flexibility. The presence of multiple buyers introduces new challenges in terms of transparency, accountability, and efficient activation of flexibility resources. The coordinator's remit encompasses enhanced visibility of market processes, intervention rights, access to relevant market results, and a communication protocol designed to ensure consistent oversight and coordination. This trend is also visible within other initiatives. For instance, GOPACS is a coordination platform, aiming to provide a level playing field for power exchanges to connect to GOPACS to sell flexibility to the SOs. At the same time, from the perspective of the SOs, GOPACS is developed to a) ensure TSO-DSO coordination, b) to allow both the TSO and DSOs to use flexibility from the distribution grid and c) to be able to respect the limits of the other SOs. In the Finnish OneNet demo, there was also an overarching coordination platform that made the procurement decisions and communicated them back to the market platforms (ID market platform and mFRR market platform), as such properly coordinating the flexibility procurement process which optimises the congestion management actions in all the interconnected SO grids included in the pilot. These developments illustrate how market design is adapting to the practical realities of multi-buyer environments and underscores the need for clear governance frameworks to support these emerging roles.

# 3 LFM design evaluation

## *3.1 Assessment framework*

As summarised in Figure 3-1, a **comprehensive assessment framework** was developed to enable a detailed evaluation of the design dimensions and choices underlying LFMs. This framework is grounded in the overarching objectives that each LFM is expected to pursue. These objectives are derived from both broader EU policy goals and general principles essential for the development of efficient, transparent, and well-functioning markets.

The assessment process begins with the identification of **high-level objectives**. These are then translated into a structured set of **assessment criteria**, which serve as the basis for evaluating various LFM initiatives. Each criterion corresponds to a specific dimension relevant to achieving the overarching objectives. For every criterion, we define **a set of indicators** that measure the extent to which the criterion is fulfilled. These indicators can be either qualitative or quantitative in nature. For each of the indicators, we will provide a scoring using a three-level scale:

- Score 1: Low score
- Score 2: Medium score
- Score 3: High score

Each score is accompanied by a clear description that explains the rationale for assigning a particular score, thereby promoting transparency and repeatability in the evaluation process. If insufficient information is available to assess an indicator for a given initiative, that indicator is omitted from the evaluation.

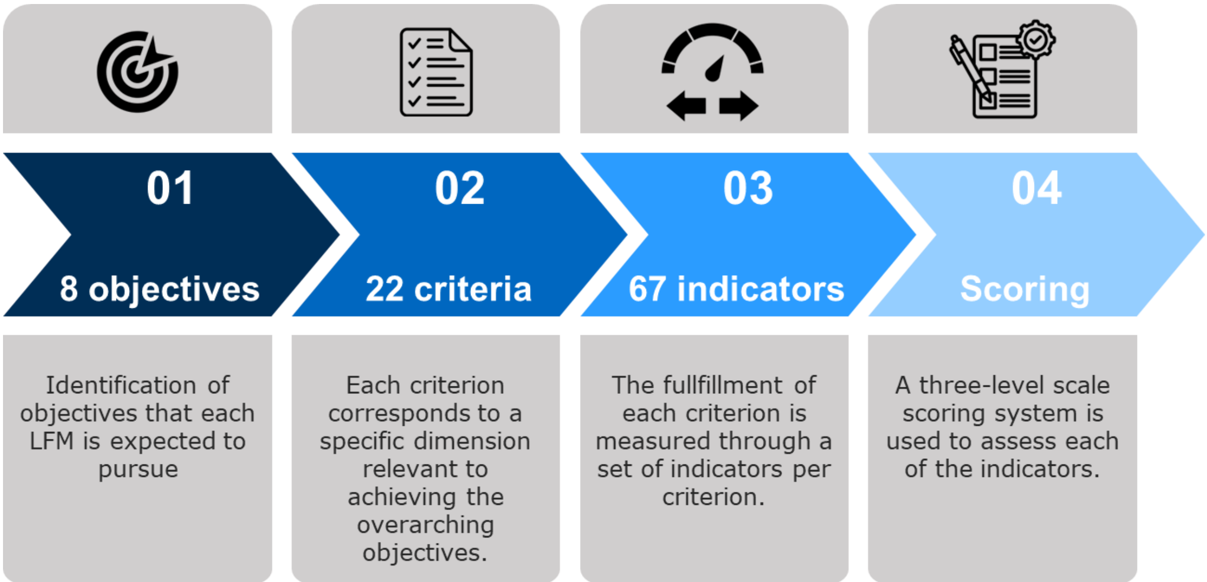

Figure 3-1: 4-step assessment framework (Source: VITO own figure).

The following overall objectives of LFM are used [7], [8], [16], [125]:

- **Objective 1 - Transparent markets**: Market transparency is defined as the availability of information about market fundamentals, activities, and outcomes. Such information is the basis for decision-making for all market participants. Transparency also implies that all market participants have access to the same information [126].
- **Objective 2 - Non-discriminatory markets**: non-discrimination implies, according to the EU-principles [127], that all stakeholders should have an equal and fair chance to access and act on markets. This means that individuals or groups of individuals who are in comparable situations should not be treated less favourably.

- **Objective 3 - Efficient markets:** Market efficiency is typically assessed through social welfare or surplus, the sum of economic surpluses across all market parties. In the context of LFM, the maximization of social welfare is generally achieved by minimizing the total costs associated with procuring flexibility. This also entails that such markets provide adequate financial incentives for resources to provide their flexibility.
- **Objective 4 - Integrated markets**: An integrated EU energy market is the most cost-effective way to ensure secure, sustainable, and affordable energy supplies to EU citizens [128]. In the context of LFMs, an integrated market setting implies a high level of alignment and coordination of the LFM with all existing wholesale electricity markets.
- **Objective 5 - Secure network operation** implies that networks need to be operated in such a way that they are safe and reliable, ensuring sufficient grid capacity to cover all energy needs at any time of the connected users and to ensure transport/distribution of energy is always possible. In the context of LFM, this means that local services must be reliably delivered and capable of effectively resolving the underlying SO need.
- **Objective 6 - Efficient network operation** guarantees an optimal allocation of resources both in the short-run (operations) and long-run (investments) to plan, operate, maintain, and invest in the electricity networks. As a result, this also entails the trade-off between different flexibility mechanisms [125].
- **Objective 7 - Consumer centricity**: Consumer centricity means taking the point of view of the consumer, when developing products, designing LFM markets, and supporting processes [16]. This entails, among others, (i) starting from the identification of the value that the consumer can bring by offering their flexibility, (ii) considering the way the consumer would experience his/her participation in the market, and (iii) capturing the fact that consumers are not all the same and may have different preferences and needs.
- **Objective 8 - Stable market design:** Stable markets are characterised by a high potential for harmonisation or standardisation and replication. Moreover, stable markets are future-proof, so they can easily adapt to possible anticipated market changes.

It should be noted that, although all the mentioned objectives are desirable for LFMs, trade-offs sometimes need to be made between them. For example, a highly integrated market setting with strong coordination with existing markets may result in reduced transparency due to its complexity, and vice versa. A complete overview of the assessment framework with the aforementioned objectives, the linked criteria, indicators, and scoring logic applied can be found in Annex 4.

### *3.2 Assessment of LFM initiatives*

In this subsection, we provide an overview of the LFM assessment. For each objective, we present and explain the distribution of scores across the different LFM initiatives for the individual indicators linked to the criteria; where possible, examples from the initiatives are included to complement the analysis[14]. In total, 32 initiatives have been assessed[15].

[14] Similar scoring schemes are sometimes used for different indicators; in such cases, we refer to the explanation provided under the relevant indicator

[15] The following initiatives have not been assessed due to a lack of available information at the time the assessment started: Pic@U ORES LFM, SCOPE ORES, Augsburg LFM, Swiss Parity demonstrator, HENEX Greek pilot. In most cases, this was due to the fact that these were markets which were still in preparation.

### *3.2.1 Objective 1: Transparent markets*

For the first objective, **transparent markets**, we identified two main criteria: *limited information asymmetry* and *information sharing*. Figure 3-2 shows the distribution of scores across the LFM initiatives for the indicators linked to these criteria (e.g. percentage of surveyed initiatives). When looking at the figure, it is clear that most initiatives exhibit limited information asymmetry and are open to sharing market rules and flexibility needs. However, there seems to be more reluctance for the majority of initiatives to share detailed market outcomes, and SOs are mostly even more hesitant to disclose detailed information on the value of flexibility. It should be noted that in the context of LFM markets, it may be less straightforward to share non-aggregated market outcomes, such as an anonymised list of submitted and cleared bids for the sake of transparency. This is because a simple merit order list is often not used, as other factors (e.g., impact factors) may influence the clearing process. In the remainder of this subsection, more detailed information will be presented for each of the indicators.

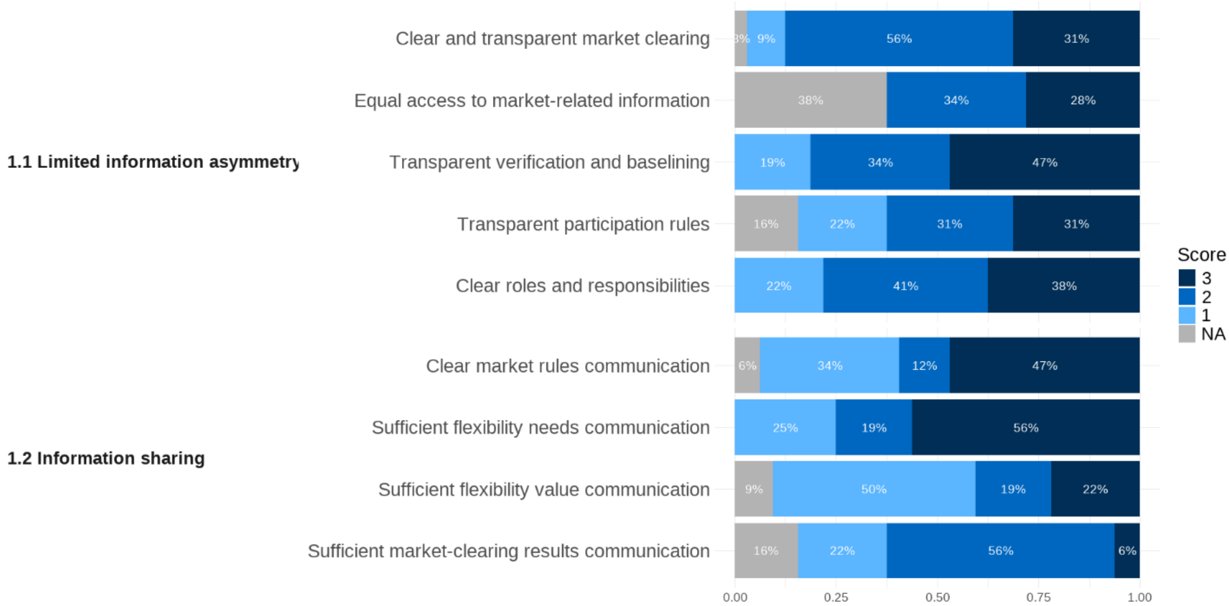


Figure 3-2: Overview of LFM assessment for objective 1 transparent markets (Source: VITO own figure).

#### 3.2.1.1 Limited information asymmetry

*Clear and transparent market clearing*

Most of the analysed LFM initiatives score reasonably well (i.e., they have at least a medium score) on transparency of the market-clearing process. A few initiatives, however, received a low score due to issues such as limited traceability (e.g., analysis by the SO outside the market that can influence clearing, or unclear rules for selecting final bids) or high complexity in market clearing (e.g., the use of an advanced network model or a coordination module connecting multiple existing markets). The majority of initiatives received a medium score. These are typically characterised by certain factors that affect traceability, such as simplified network representations in the market or the use of impact factors, smart orders, complex remuneration schemes, and/or TSO-DSO coordination during procurement. Initiatives with the highest scores typically feature automated market clearing without network consideration, allowing for clearing based solely on a pure economic merit order.

*Equal access to market-related information*

In terms of equal access to information, several initiatives did not prioritise this aspect, as they were either still in a pilot or research phase or had not yet specified this topic. However, the initiatives that did address it generally received positive scores (at least medium). None of the LFM initiatives exhibited privileged access to specific information for certain market participants, which would have resulted in a low score. However, in quite a few cases, information was shared equally with existing market participants but not with potential new entrants. This occurred, for example, when market information (e.g., flexibility needs or value) was shared only through a market platform and not publicly, or when access to market area and grid node data was restricted to existing FSPs. Nine initiatives provided fully equal and transparent access to market-related information for both existing and potential market participants.

*Transparent verification and baselining*

Most LFM initiatives also scored well on the transparency of the verification process, including baselining. Fifteen initiatives implemented automatic verification and used either i) a transparent baseline method or ii) an alternative approach that does not require baselining (e.g., defining capacity-limited products or using operating envelopes). Eleven initiatives received a medium score, as their verification process is established but is still manual, and/or they lack a fully agreed-upon baselining method deemed suitable for the local service. Six initiatives received a low score because they do not yet have an established verification process. In these cases, the methodology is still under discussion, the current process is unsuitable for the local service, or there is a lack of sufficient data for verification.

*Transparent participation rules*

Scores for this criterion were more diverse across the initiatives. Five initiatives, mainly in a demo phase, did not focus on the PQ process and thus did not develop formal participation rules. Seven initiatives received a low score due to an underdeveloped or overly complex registration process, in some cases with a PQ process involving substantial manual steps. Twenty initiatives (medium and high scores) had automated PQ processes and clearly available participation rules. Half of these applied at least one additional measure to simplify the process (e.g., simplified PQ for small flex assets or similar asset types, using batch upload, PQ based on resource group characteristics, PQ at aggregated pool level, easy switching of assets, common procedures across markets/services), and therefore received a high score.

*Clear roles and responsibilities*

Most initiatives had clear roles and responsibilities. Twelve initiatives provided an unambiguous definition of roles, including that of the LMO, corresponding to a score of 3. Thirteen initiatives showed partial clarity, with some overlaps or gaps in responsibilities, or concerns regarding neutrality or potential market distortions. Examples include uncertainty over SO involvement in bid selection, unclear service verification roles, and ambiguity around who sends activation signals or provides meter data. In seven initiatives, exact roles and responsibilities were still to be defined. These were typically demo projects in which decisions about role allocation - such as who assumes the LMO role or other newly identified roles (e.g., TSO-DSO coordination platform operator, flexibility register operator) - had not yet been finalised.

#### 3.2.1.2 Information sharing

*Clear market rules communication*

For this first indicator, results were mixed, with both low and high scores observed. Eleven initiatives did not communicate market rules, as the markets and the rules were still under development. Four initiatives had defined market rules, but they were only limitedly accessible (e.g., rules included only in regulatory documents or not made public). For fifteen initiatives, the market rules were publicly available and clearly communicated well ahead of market launch. Communication methods included public market announcements, information sessions, and publication of market rules. Some initiatives also publicly shared detailed product sheets and contract templates.

*Sufficient flexibility needs communication*

Eight initiatives did not communicate their flexibility needs. Reasons included the pilot nature of the initiative, ongoing development of means to share flexibility needs (e.g. congestion maps), or a deliberate decision to avoid gaming. Six initiatives offered limited communication on flexibility needs. This included grid state information (e.g., congestion maps), market area and node location, high-level needs shared via Network Development Plans (NDPs), or ahead of LT procurement. The majority of initiatives adopted more dynamic communication, sharing effective flexibility needs prior to LT and/or ST procurement, or using an open order book with explicit buy orders from the SO. Some of these also provided additional details such as expected market lifetime, activation probability, and estimated number of activations.

*Sufficient flexibility value communication*

Three initiatives were still deciding whether to share any indication of the value of flexibility for the procuring SO. Half of the initiatives did not provide any value indication, due to the same reasons as indicated for the previous indicator (i.e. pilot setting, ongoing development, or to prevent gaming). Six initiatives shared static value indications, including a fixed price for LT procurement, bidding price limits, and indicative price levels. Finally, seven initiatives used a dynamic value communication approach, such as disclosing a maximum price during ST procurement or an open order book with explicit buy orders from SO.

*Sufficient market-clearing results communication*

Most initiatives disclosed, with different temporal/geographic granularity depending on the initiative, aggregated market outcomes such as total procured/offered volumes, max/min/average prices, and the number of participating FSPs. These received a medium score. Seven initiatives did not share any market-clearing results, with only the individual trade history available to each FSP. This was often due to the pilot phase or incomplete market implementation. Two initiatives shared non-aggregated results; One published all accepted and offered bids, including prices. The other used an open order book where the volume and price of orders are visible to all market participants.

### *3.2.2 Objective 2: Non-discriminatory markets*

For the second objective, **non-discriminatory markets**, three main criteria were identified: *technology-neutrality, minimised entry barriers*, and *fairness*. Figure 3-3 shows the distribution of scores across the LFM initiatives for the indicators linked to these criteria. As shown in the figure, the LFM initiatives generally perform well in terms of technology neutrality, which assesses whether the market design avoids favouring specific technologies, while the criterion minimised entry barriers is more moderately addressed by the LFM initiatives. Under the criterion of fairness, the initiatives display a wide range of scores, indicating varied approaches and performance levels across the initiatives. In the remainder of this subsection, each indicator will be discussed in more detail.

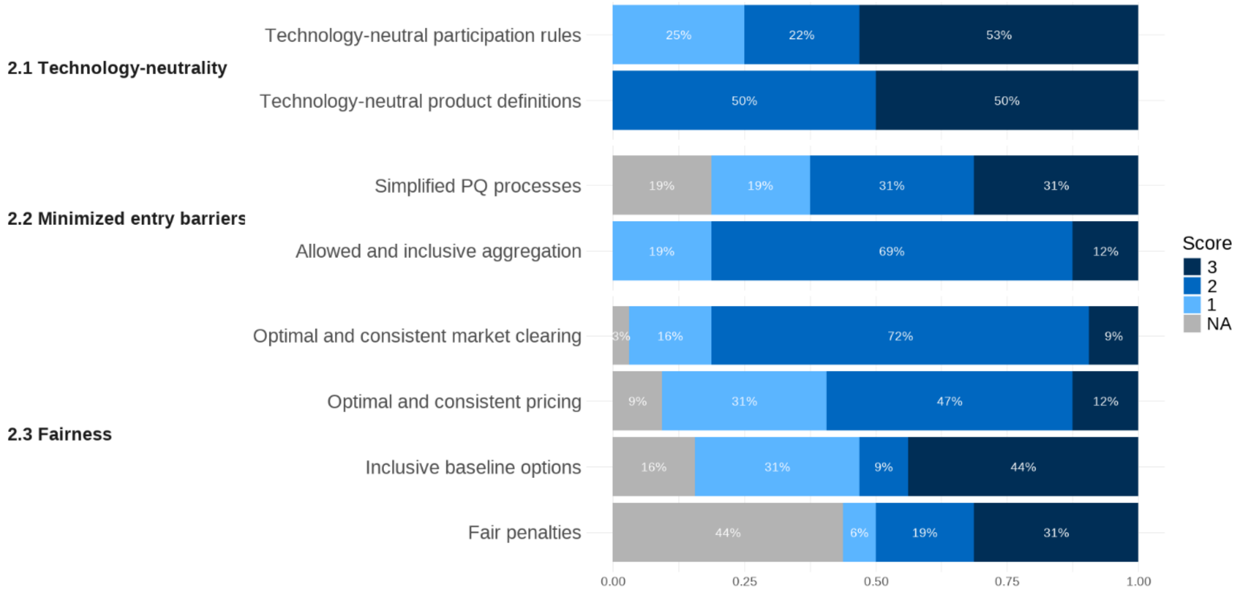


*Figure 3-3: Overview of LFM assessment for objective 2 non-discriminatory markets (Source: VITO own figure).*

### 3.2.2.1 <u>Technology-neutrality</u>

*Technology-neutral participation rules*

Regarding technology-neutral participation rules, seventeen initiatives received the highest score. This indicates that their participation rules were fully technology-neutral, meaning they did not impose discriminatory conditions based on the type of technology used. In contrast, eight initiatives received the lowest score. These initiatives restricted participation to specific types of assets or grid users. In some cases, this limitation stemmed from the fact that the initiative was a demonstration project, where only participating demo assets were eligible. In other instances, participation was limited to particular categories of grid users, such as residential, commercial, or industrial users, or to specific technologies, such as those capable of providing reactive power or large-scale generation units. Seven initiatives were assigned a medium score. Although these allowed all connected assets to participate in principle, they imposed certain minimum requirements or thresholds that impacted technology neutrality. For example, some initiatives required a minimum asset size for eligibility[16] or restricted participation to assets connected above a certain grid level.

*Technology-neutral product definitions*

The assessment of technology-neutral product definitions yielded even more positive results. Half of the initiatives received a medium score (score 2), and the other half received a high score (score 3), indicating that product definitions were largely technology-neutral across the studied LFMs. No initiative received a low score on this indicator. For the initiatives that had a medium score, the product characteristics posed some participation challenges for certain technologies. This was observed in LFMs that offered

[16] With low minimum asset sizes (i.e. lower than 1 kW) we also gave a score of 3 in case there were no other restrictions.

only LT procurement, which can deter participation from certain types of assets for which it is difficult to plan well ahead. Additionally, products with low full activation times, long delivery durations, or a combination of minimum bid size requirements and restrictions on aggregation can make it difficult for some technologies to participate. In contrast, initiatives that received a high score typically offered a combination of products that facilitated broad participation from diverse technologies. These often included both capacity and energy products, as well as the option to submit free bids. Furthermore, several of these initiatives provided flexibility for FSPs to define specific parameters, such as minimum and maximum activation durations or rest periods required after activation, which further enhanced the technology-neutral nature of the products.

#### 3.2.2.2 Minimised entry barriers

*Simplified PQ Processes*

The responses regarding simplified PQ processes are relatively diverse, indicating varied practices among the initiatives. Six initiatives did not address PQ at all. Another six received a low score, as their PQ processes were not well adapted to the FSPs and their assets participating in the LFM. This was typically the case when the PQ process was originally designed for larger flexibility assets or more demanding services, which often resulted in manual steps or strict financial and administrative requirements. The majority of initiatives received a medium or high score (scores 2 or 3), indicating they had a standard PQ process with limited complexity. About one-third of all initiatives received the highest score, since they implemented additional simplification measures. Examples of these simplifications are provided in section 0 as part of the explanation for the indicator *transparent participation rules.*

*Allowed and Inclusive Aggregation*

In six initiatives, aggregation was not allowed. This restriction was either due to the testing phase or the specific nature of the service being procured (e.g. provision of RP). However, aggregation was allowed in over 80% of the initiatives, those scoring 2 or 3. Among these, only a few had already implemented additional supportive measures, which qualified them for the highest score (score 3). Such measures include the use of aggregated baselines, settlement at the portfolio level, and mechanisms to dynamically adapt portfolios based on the location of the flexibility need.

#### 3.2.2.3 Fairness

*Optimal and consistent market clearing*

Regarding the indicator optimal and consistent market clearing, most initiatives (23) received a medium score. This suggests that although the market-clearing mechanisms generally aim to minimise cost, several factors may still result in sub-optimal outcomes. These factors include continuous trading, manual interventions, gate closure times far ahead of delivery, reliance solely on LT procurement, separate and unlinked clearing processes for different products, SO intervention in the clearing process, undefined or variable GCTs, and prioritisation of local constraints. Five initiatives received a low score, with clear evidence that their market-clearing processes do not ensure cost minimisation. In these cases, volumes are sometimes filled by the SO on a first-come, first-served basis, contracts are allocated on a rolling basis as part of LT procurement, market objectives prioritise volume maximisation over efficiency, or the selection of FSPs is limited by fixed caps in terms of the number of FSPs. In contrast, three initiatives were judged to ensure both cost minimisation and consistency and thus received a high score. One of these uses CGA with a GCT close to the time of delivery, another combines LT and ST procurement with a requirement for LT products to bid into the ST market, and the third operates within a common market setting with a consistent clearing mechanism.

*Optimal and consistent pricing*

For this criterion, the distribution of scores was more varied. Fifteen initiatives scored medium, ten scored low, and only four scored high. This variation suggests that within many initiatives, pricing mechanisms still lack full optimality, with price signals often failing to reflect real-time local grid conditions in LFMs. Initiatives with low scores demonstrated pricing approaches likely to result in overpayment for flexibility, including fixed prices, first-come-first-served systems, continuous trading, bidding price limits, or prices set far in advance of delivery. Medium-scoring initiatives used pricing schemes with limited granularity, where flexibility was valued uniformly without consideration of the specific network location. Only four initiatives achieved a high score, demonstrating pricing mechanisms where price signals were aligned with real-time and location-specific grid conditions.

*Inclusive baseline options*

This indicator also produced mixed results. Many initiatives are still exploring suitable baselining methods that are tailored to the characteristics of LFMs and the diverse types of flexible resources involved. Ten initiatives relied on a single traditional baselining method, such as the "meter-before-meter-after" (MBMA) approach or statistical approaches, typically already used in non-LFM contexts. These received a low score. Three initiatives received a medium score, as they supported multiple traditional baselining methods. However, fourteen initiatives were awarded the highest score, as they offered one or more baseline approaches specifically adapted to the needs of LFMs or to the specific nature of the flexible resources. These included using nomination baselines, using capacity limitation products or leveraging operating envelopes, which do not require baseline calculations, allowing FSPs to propose their own baselining methodology or select it from a list, or introducing tailored baselines for reactive power flexibility delivery.

*Fair penalties*

Lastly, the indicator fair penalties showed the weakest performance within the fairness criterion. Fourteen initiatives were marked as not applicable, as no penalty schemes were defined at the time of assessment. Of the remaining initiatives, two received a low score, either because there were no consequences for non-delivery (i.e. remuneration was still provided despite non-delivery) or because penalties were considered unreasonably high, thereby creating a risk of deterring participation. The latter was the case for one initiative where penalties were applied for contractual breaches even in cases of partial delivery. Six initiatives were scored medium, offering penalty schemes that were somewhat reasonable but not well-aligned with incentivising truthful bidding or consistent performance. These schemes often appeared arbitrary or disconnected from the actual delivery outcomes. In contrast, ten initiatives earned a high score, having established or planned well-designed and proportionate penalties for non-delivery. These schemes typically included pro-rata payment systems based on delivered volume, minimum thresholds for remuneration, and reduced availability payments tied to delivery performance. One of the LFM initiatives based its penalties on the imbalance price in cases of congestion-related non-delivery.

### *3.2.3 Objective 3: Efficient markets*

To assess the objective of **efficient markets**, we identified three key criteria: *economic efficiency, high liquidity*, and *minimised risk of gaming*. Figure 3-4 shows the distribution of scores across the LFM initiatives for the indicators linked to these criteria. Overall, the LFM initiatives show highly diverse scores on the economic efficiency indicators. Typically, they score medium to high on market coordination, maximisation of social welfare, and automatic clearing, while receiving lower scores for the consideration of network constraints. Assessing the liquidity of the surveyed LFMs has proven challenging due to a lack of appropriate data. Nevertheless, it is evident that liquidity in the studied initiatives remains rather limited. This is also reflected in the scores for the lower scores on the indicators linked to minimised risk of gaming, which is closely linked to liquidity. In the remainder of this subsection, each indicator will be discussed in more detail.

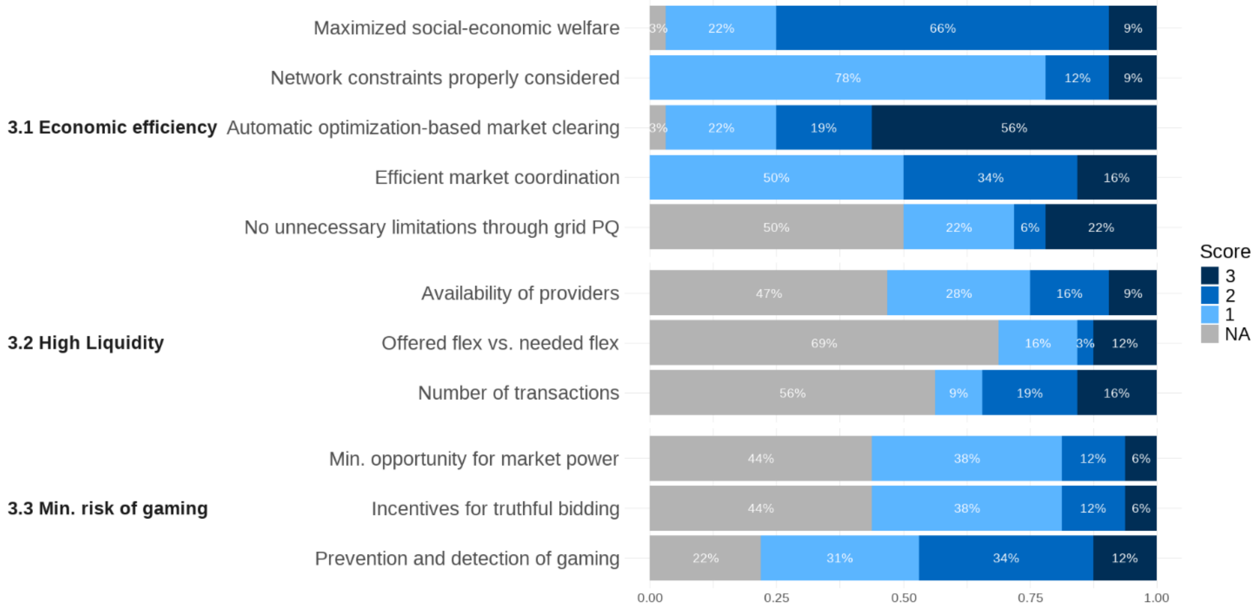


*Figure 3-4: Overview of LFM assessment for objective 3 efficient markets (Source: VITO own figure).*

#### 3.2.3.1 Economic efficiency

*Maximised socio-economic welfare*

The majority of studied LFMs aim to minimise total procurement costs. However, certain features still contribute to sub-optimal outcomes. These include the absence of grid representation in the market design, continuous trading mechanisms, LT procurement only, and non-optimal pricing structures. For these reasons, twenty-one initiatives received a medium score. Three initiatives received the highest score. These applied automated market-clearing processes that ensure optimal outcomes, featuring network-aware clearing, CGA with CGT close to delivery time, and cross-product optimisation within the LFM. Seven initiatives were assigned a low score due to clear evidence of inefficient clearing mechanisms, such as SO intervention in the market-clearing, a focus on maximizing procured volume rather than minimising costs, fixed pricing schemes, or a capped number of market participants.

*Network constraints properly considered*

In most LFM initiatives (25), network constraints are not adequately integrated into the market-clearing process. Instead, these initiatives define market areas based on network information[17], often during PQ, with limited or infrequent updates. In many of the initiatives with a low score, the calculation of constraints is handled externally by the SO rather than integrated into the market design. Four initiatives received a medium score, having implemented network representations through impact factors either defined during PQ or updated more regularly. Only three initiatives received the highest score, as they incorporated a full network model directly into the market-clearing process.

*Automatic optimisation-based market clearing*

We also assessed whether market clearing was conducted through automatic, optimisation-based mechanisms, as opposed to manual bid selection, which can lead to inefficiencies[18]. A majority of the initiatives (18) use fully automated clearing methods. Six others apply automated processes that are subject to a final validation by the procuring SO. In contrast, seven initiatives still rely on manual selection by the SO, potentially leading to inefficiencies, certainly when the LFM would be scaled up.

*Efficient market coordination*

The degree of coordination with other markets varies significantly across the initiatives. Half of the LFMs currently operate without coordination, functioning as separate SO LFMs. These markets typically do not align with the scheduling or operation of other markets, for example, by relying solely on LT procurement, maintaining overlapping timeframes, or a separate SO LFM for RP is set up. In some of these cases, there is only a single DSO in the MS. Eleven initiatives use a sequential market approach, coordinating the sequence of trading windows with existing markets and allowing for manual bid forwarding. Some of these initiatives also include additional features to facilitate participation across markets, such as automatic bid forwarding, releasing unused bids to enable participation elsewhere, and setting minimum notice periods for activation. Finally, five initiatives implement a common market model with bid pooling across products/services. These include common TSO-DSO markets for congestion management solely and common TSO-DSO platforms for both congestion management and balancing.

*No unnecessary limitations through grid PQ*

The final indicator evaluates whether grid PQ can result in unnecessary limitations, namely, excluding too much flexibility from participating in the market. Two key observations emerge. First, most initiatives (16) do not yet apply any form of grid PQ. Second, among those that do, roughly half use a static approach, creating a risk of overly restrictive margins. Within these initiatives, PQ checks are often done only once or updated infrequently (e.g. annually or seasonally). Two initiatives received a medium score by implementing more dynamic PQ processes, updated on a monthly or weekly basis, thus reducing the risk of unnecessarily excluding flexibility. Finally, seven initiatives received the highest score for applying dynamic grid PQ, updated for every market session. These approaches include real-time grid checks by the impacted SO after market clearing, temporary limit updates per session, dynamic TLS, or full integration of grid constraints directly into the market-clearing process for all affected grids.

[17] A few of these initiatives implement the possibility to link market areas which does improve the network representation.

[18] It should be noted that for LT procurement with a limited number of providers manual selection could still lead to optimal clearing results and is therefore deemed acceptable.

#### 3.2.3.2 Liquidity

The second indicator evaluates the liquidity of LFMs. As already indicated, assessing the liquidity of the surveyed LFMs is inherently challenging, as it requires objective, consistent, and comparable data across initiatives. Key indicators for this assessment include the *number of available FSPs*, *the ratio offered versus needed flexibility* and *the number of available FSPs number of transactions.* As illustrated in Figure 3-4 most initiatives were unable to provide such data. This is primarily due to two reasons: in some cases, the data are not publicly available due to confidentiality concerns; in others, the data are simply not yet collected, particularly for LFMs that are still in early development or pilot phases. As a result, a clear picture of market liquidity cannot be given. Nevertheless, it is apparent that, in general, LFMs are still rather immature and therefore cannot yet be considered liquid markets.

*Availability of providers*

Among the initiatives that did provide data, a few more mature markets reported relatively high numbers of FSPs, up to 40 and, in one case, over 160. However, these are exceptions. The majority of markets report fewer than 20 FSPs, which corresponds to either a low or medium liquidity score, and 9 of these had fewer than 10, corresponding to the lowest score. It is important to note, however, that the absolute number of providers does not always directly reflect insufficient liquidity. In some cases, even a small number of FSPs is sufficient to meet the current local flexibility demands. Conversely, in other markets, a larger number of FSPs may be necessary to adequately respond to flexibility needs due to the scale of required services.

*Ratio of offered flexibility to needed flexibility*

Data on the ratio of offered to needed flexibility were generally scarce. Only a limited number of initiatives were able to provide this information. Among those, five initiatives reported that the flexibility offered was lower than the required amount. One initiative reported a balance between offered and needed flexibility, while four initiatives indicated that the flexibility offered exceeded the needed capacity. Although these numbers are too small to draw definitive conclusions, they suggest varying levels of demand-supply alignment across the initiatives.

*Number of transactions*

The number of transactions is another relevant metric for assessing liquidity. Here, too, data was limited. Of the initiatives that shared transaction data, three were categorised as having a low number of transactions, six reported a medium number, and five demonstrated a high number of transactions.

#### 3.2.3.3 Minimised risk of gaming

The final criterion for the objective of efficient markets is the minimised risk of gaming. This assessment focuses on three key aspects: *market power opportunities, incentives for truthful bidding,* and *prevention and detection of gaming.* Several design factors can create opportunities for gaming, including highly localised flexibility needs served by a limited number of providers, low initial participation from FSPs, significant and structural grid limitations, and fragmented market structures. All of these factors are closely linked to overall market liquidity. For the first two indicators, market power opportunities and incentives for truthful bidding, we refer to the discussion in section 3.2.3, as they are covered in the context of market liquidity.

With respect to the third indicator, *mechanisms for preventing and detecting gaming*, only a few initiatives (specifically, four) have already implemented mature systems aimed at addressing these risks. Approximately one-third of the initiatives have adopted more ad hoc or preliminary measures. This indicates that comprehensive solutions are not yet widely established across the surveyed LFMs.

### *3.2.4 Objective 4: Integrated markets*

For the overall objective of creating **integrated markets** we identified four main criteria: *TSO-DSO coordination, DSO-DSO coordination, alignment with existing markets,* and *optimal utilisation of resources across markets.* Figure 3-5 shows the distribution of scores across the LFM initiatives for the indicators linked to these criteria. Overall, most of the LFM initiatives currently exhibit a rather limited level of coordination across SOs and markets. Only in the area of baseline procedures is it clear that LFMs draw on the experience of existing markets to select their baseline approaches. Additionally, the possibility of participating in multiple markets is considered in at least the majority of LFMs (through manual or automatic bid forwarding and proper alignment of LFM timings with timings of existing markets). Bid formats, however, are still mostly uncoordinated. In the remainder of this subsection, each indicator will be discussed in more detail.

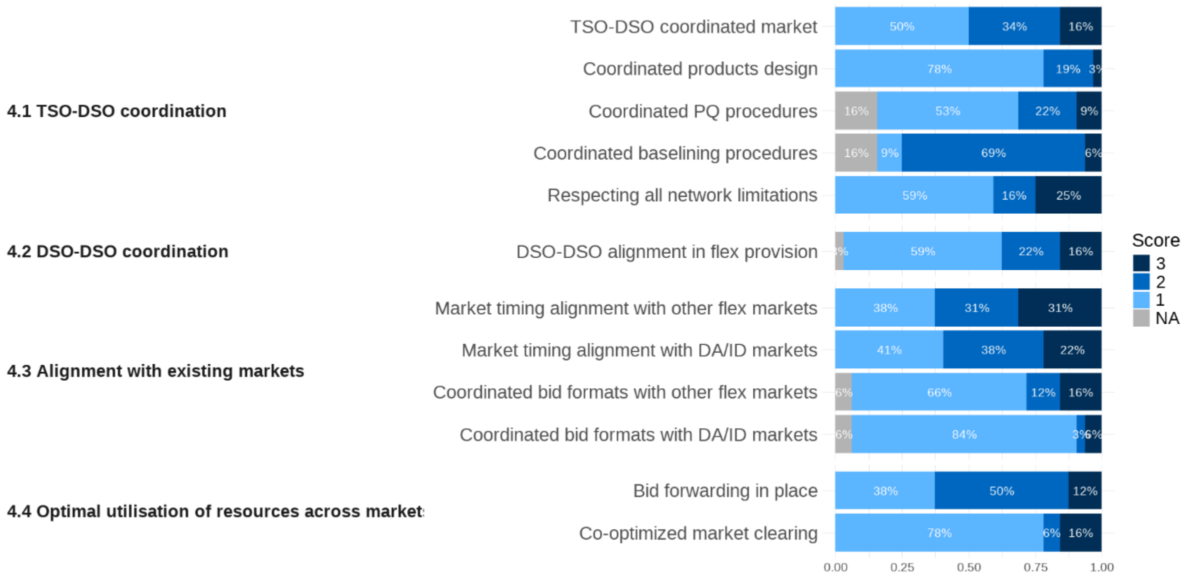


*Figure 3-5: Overview of LFM assessment for objective 4 integrated markets (Source: VITO own figure).*

#### 3.2.4.1 <u>TSO-DSO coordination</u>

*TSO-DSO coordinated market*

As previously explained, the studied LFMs differ in their level of coordination, ranging from standalone operations to sequentially aligned markets and fully integrated common platforms. Figure 3-5 illustrates that half of the initiatives lack meaningful coordination with other markets. For more information, we refer to the indicator *efficient market coordination* as part of the criterion *Economic efficiency* (section 3.2.3).
*Coordinated products design*

The majority of initiatives (25) receive a low score, indicating that the products are based on the specific needs of individual SOs. Some coordination at the MS level may occur in designing these local products. Six initiatives receive a medium score; in these cases, the products are based on or inspired by existing TSO balancing products, most commonly mFRR. One initiative receives a high score of 3, as the LFM product is essentially equivalent to the mFRR product. In this particular case, the mFRR product is used to address both DSO and TSO congestion in a common market, allowing for bid forwarding to the mFRR market afterwards.

*Coordinated PQ procedures*

Overall, the initiatives demonstrate a low level of coordination in their PQ processes. A total of seventeen initiatives received a low score, indicating that PQ is conducted solely at the level of the LFM, without coordination with other markets or services. Seven initiatives received a medium score, reflecting some degree of coordination in their PQ procedures. This may include features such as a common flexibility register, the avoidance of duplicate PQ processes, alignment with standardised guidelines at MS level, sometimes including coordinated checks. Finally, three initiatives received a high score, representing the highest level of coordination, where a single PQ process is used across multiple DSO and TSO services, enabling streamlined access for FSPs and flexible resources to various flexibility markets.

*Coordinated baselining procedures*

In the majority of cases, there is some degree of coordination related to baselining, i.e. a total of twenty-two initiatives received a medium score, indicating that the baseline method is defined at the LFM level, but it follows a similar approach to those used in other markets, such as balancing. In some countries, like the United Kingdom, there is a predefined list of acceptable baselining methods established at the MS level to guide implementation. Three initiatives received a score of 1, where baseline methods were defined specifically at the LFM level. In some of these cases, alternative approaches are used instead of traditional baselines: one initiative requires the FSP to operate assets within a defined operating envelope, while two others apply a capacity limit approach. Finally, two initiatives achieved a score of 3, as they use the same baseline methodology as applied in existing markets, ensuring full alignment across markets.

*Respecting all network limitations*

Nineteen initiatives received a low score, indicating no consideration of impacts on other grids. In these cases, flexibility is procured and activated without assessing potential consequences for neighbouring or interconnected systems. Five initiatives were scored at level 2, where impacted grids are taken into account as part of the PQ process. This involves a static PQ assessment, where assets located in the grid of another SO must first receive approval from the SO where they are connected before being permitted to participate in another SO's market. Eight initiatives achieved the highest score, reflecting a more advanced and dynamic approach. These initiatives incorporate the consideration of impacted grids either during procurement or through highly dynamic grid-aware PQ processes conducted for every market session. A variety of mechanisms are used: for example, a traffic light system is implemented when the TSO procures flexibility from assets connected to the DSO grid; Alternatively, the impacted SO may apply restrictions after market closure or dynamically impose constraints on a daily or even ID basis to prevent operational issues resulting from activations by other SOs; In some cases, grid constraints from all impacted DSOs and TSOs are directly integrated into the market clearing process, ensuring all network limitations are respected.

#### 3.2.4.2 DSO-DSO coordination

*DSO-DSO alignment in flex provision*

The level of coordination between DSOs across the surveyed LFM initiatives varies significantly. A majority of nineteen initiatives received a low score, indicating no current DSO-DSO coordination. Seven initiatives scored 2, reflecting some alignment in market design, processes, or products. Only five initiatives achieved a high score, demonstrating active DSO-DSO coordination during procurement—either through a sequential setup (e.g., local DSO followed by regional DSO) or participation in common SO markets involving multiple DSOs.

#### 3.2.4.3 Alignment with existing markets

*Market timing alignment with other flex markets*

The degree to which LFMs align their timing with balancing markets is quite evenly spread across the initiatives. Twelve initiatives received a low score, indicating no consideration of the timing of balancing markets. In these cases, the clearing and activation of flexibility occurs very close to real time, or the LFMs use LT tenders with activation signals also issued close to real time. This leaves very little opportunity for flexibility providers to participate in other markets. Ten initiatives are assigned a medium score, where certain measures are in place to facilitate participation in both the LFM and balancing markets. These measures include mechanisms such as freeing up bids at a specific time to enable participation in following markets, allowing FSPs to define minimum notice periods for activation, or structuring the market with a combination of an auction phase (held before the DAM) and a continuous trading phase (after the DAM). Such arrangements provide some flexibility for FSPs to participate in other markets. Another ten initiatives achieve the highest score, representing the highest level of coordination. These have a sequential market design, so that FSPs can participate in the LFM as well as balancing markets or they are common markets with joint procurement of local services and other flexibility services.

*Market timing alignment with DA/ID markets*

When examining the alignment of LFM timings with DA and ID wholesale markets, the degree of coordination appears to be somewhat lower than the alignment observed with other flexibility markets. While some initiatives have established a fully sequential market structure that links LFMs, TSO balancing markets, and wholesale markets in a sequential manner, others only consider the timing of TSO balancing markets when designing their market schedules. Thirteen initiatives received a low score, indicating no consideration of the timing of wholesale markets. Twelve initiatives achieved a medium score, where certain measures are in place to enable participation in both LFMs and wholesale markets. Seven initiatives received the highest score, reflecting a sequential market design or a setting where the procurement of local services is integrated into the structure of wholesale markets. The latter is the case for two initiatives, i.e. where LFM bids are traded in the ID wholesale market.

*Coordinated bid formats with other flexibility markets*

Most of the LFMs did not coordinate their bid formats with other flexibility markets yet. A total of twenty-one initiatives received a score of 1, indicating no coordination of bid formats. Four initiatives were assigned a medium score, reflecting a moderate level of coordination. These initiatives feature DSO-specific products and bid formats but incorporate some alignment with the mFRR bid format. Five initiatives achieved the highest score of 3, representing full harmonisation of bid formats. In these cases, the bid formats used in the LFM were fully aligned, allowing seamless bid forwarding and integration across both DSO and TSO markets.

*Coordinated bid formats with DA/ID markets*

Similar, but somewhat lower scores can be found for coordinated bid formats with DA/ID markets. The majority of initiatives (27) use uncoordinated bid formats, while one shows some coordination and two have fully harmonised bid formats. It should be noted that in the latter case, the alignment is with the ID wholesale market.

#### 3.2.4.4 Optimal utilisation of resources across markets

*Bid forwarding in place*

The level of bid forwarding functionality varies across the initiatives. Twelve initiatives received a score of 1, as they did not enable bid forwarding due to a lack of alignment in market timings, preventing even manual forwarding. Sixteen initiatives scored 2, allowing manual bid forwarding by FSPs, made possible through a sequential market setup. Four initiatives achieved a score of 3, implementing automatic bid forwarding, specifically toward the mFRR market.

*Co-optimised market clearing*

Most studied LFMs were separate SO markets. Consequently, the majority of them (25) received a score of 1, operating with separate order books at the LFM level, independent from other markets. Two initiatives scored 2, using common order books with other markets but maintaining separate clearing processes: one had a shared order book among different DSOs (local and regional), and the other between the TSO and DSO. Five initiatives reached the highest score of 3, implementing common order books with joint clearing. Among these, three used a common TSO-DSO market for congestion management (one of these also integrated with an ID wholesale market), two combined DSO congestion management and TSO balancing in a single and common market, and one fully integrated LFM bids into the ID wholesale market.

### *3.2.5 Objective 5: Secure network operation*

The **security of the network operation** is assessed through two criteria: *effectiveness in solving the need of the SO* and *operational security*. Figure 3-6 shows the distribution of scores across the LFM initiatives for the indicators linked to these criteria. Operational security indicators overall have a considerable low scoring, while in terms of effectiveness in solving the SO need, the assessment is rather mixed for the surveyed LFMs. In the remainder of this subsection, each indicator will be discussed in more detail.

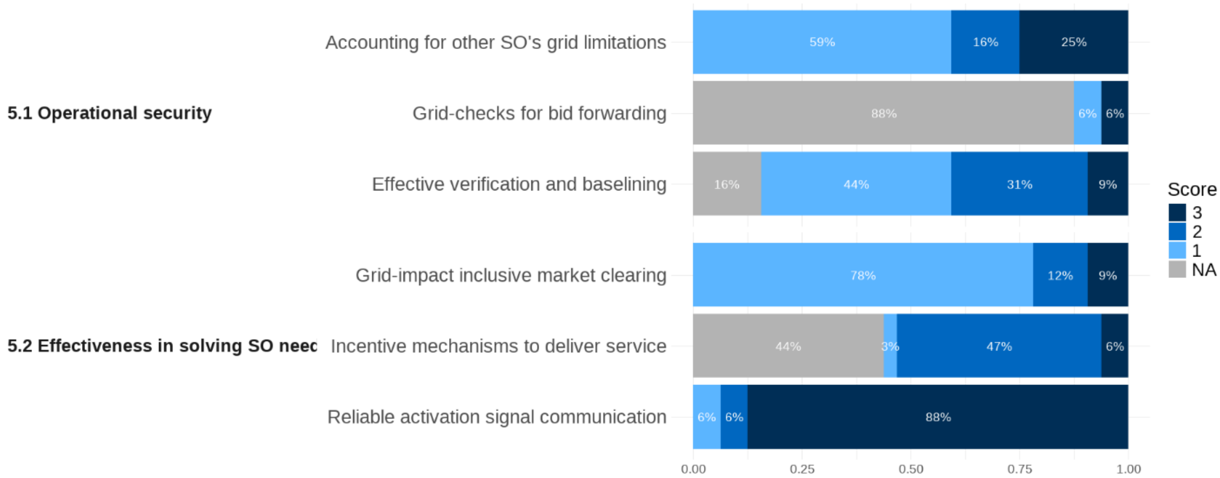


*Figure 3-6: Overview of LFM assessment for objective 5 secure network operation (Source: VITO own figure).*

### 3.2.5.1 <u>Operational security</u>

*Accounting for other SO's grid limitations*

The scoring applied for the first indicator accounting for other SO's grid limitations, is the same as for the indicator *respecting all network limitations* under the criterion TSO-DSO coordination (see section 3.2.4). The majority of LFM initiatives (19 initiatives) currently do not account for grid limitations when procuring flexibility from outside of an SO's own operational area. Five initiatives adopt a PQ approach with low update frequency, while eight initiatives apply very dynamic grid checks.

*Grid-checks for bid forwarding*

The majority of initiatives (28) do not apply automatic bid forwarding. Only four initiatives explored bid forwarding, and in all four cases, this was to the mFRR market. In two of these, automatic bid forwarding was tested for a limited period, but without a grid check, resulting in a low score. The other two initiatives developed solutions incorporating dynamic grid checks and thus received a high score. In one initiative, a dynamic grid check was performed before forwarding bids to the mFRR market (MARI) to check that the activation of the bids would not aggravate congestion. This was carried out by first checking if the activation of the complete set of bids eligible for forwarding would cause network violations (which is carried out using power flow calculations). If violations occur, the costliest bids are iteratively filtered out until a set of safe bids is reached. In the other, a process has been developed that includes a filtering step based on grid constraints, with the aim of re-running the market-clearing optimisation. This approach seeks to maximise the volume that can be forwarded while respecting all temporary limits set by DSOs and TSOs, thereby ensuring that forwarded bids do not create additional congestion.

*Effective verification and baselining*

For the indicator effective verification and baselining, a similar scoring approach is applied as for the indicator *inclusive baseline options* (see section 3.2.2.3 Fairness under the objective non-discriminatory markets). However, for this indicator, more initiatives receive a medium score rather than a high score, as most do not currently apply baseline monitoring. Only three initiatives have implemented a process for baseline monitoring and therefore received a high score.

#### 3.2.5.2 Effectiveness in solving SO need

*Grid-impact inclusive market clearing*

For this indicator, the same scoring approach applies as for the indicator *network constraints properly considered*. Overall, only a minority of the studied LFM markets currently include a network representation in the market. More information can be found in section 3.2.3.1.

*Incentive mechanisms to deliver service*

Almost half of the initiatives (14) were marked as not applicable, as no penalty schemes were defined at the time of assessment. Another 15 initiatives received a medium score, indicating some incentive to provide the committed local service. This typically involves an actual obligation, such as a requirement to bid in the ST market with reserved capacity and/or reduced payment in case of non-delivery or partial delivery. One initiative received a score of 1, reflecting a low incentive to deliver the committed service, with no real obligation or consequence for non-delivery. In this case, the FSP got paid even if they did not deliver. Two initiatives received a score of 3, representing a high incentive to deliver, where an actual obligation is combined with additional financial penalties in case of non-delivery. For more information on the penalties, we refer to the indicator *fair penalties* within section 2.2.3.4.

*Reliable activation signal communication*

The means of activation signalling vary across the studied initiatives, but most of them do use an automatic activation signal. Two initiatives received a low score, indicating that no explicit activation signal is provided. In these cases, the market outcome itself defines the modalities under which the service is to be delivered, for example, through a predefined LT delivery schedule, meaning that no further activation step is used. Another two initiatives received a medium score, where activation is communicated manually, i.e. via phone or email. Finally, initiatives that received the highest score (28 initiatives) have implemented automatic activation signals. These are sent either through the market platform or directly by the procuring SO. In some of these cases, manual activation remains an option, particularly when technical integration, such as through APIs, has not yet been fully realised for certain FSPs.

### *3.2.6 Objective 6: Efficient network operation*

The objective **efficient network operation** will be analysed based on two main criteria, i.e. *optimal utilisation of flexibility mechanisms* and *synergy with other flex mechanisms*. Figure 3-7 shows the distribution of scores across the LFM initiatives for the indicators linked to these criteria. From the figure, it is clear that a lot of initiatives could not provide information on the trade-off between flexibility and investment on the one hand and the trade-off between or impact of different flexibility mechanisms on the other or did not have a lot of experience on the topic yet. In the remainder of this subsection, each indicator will be discussed in more detail.

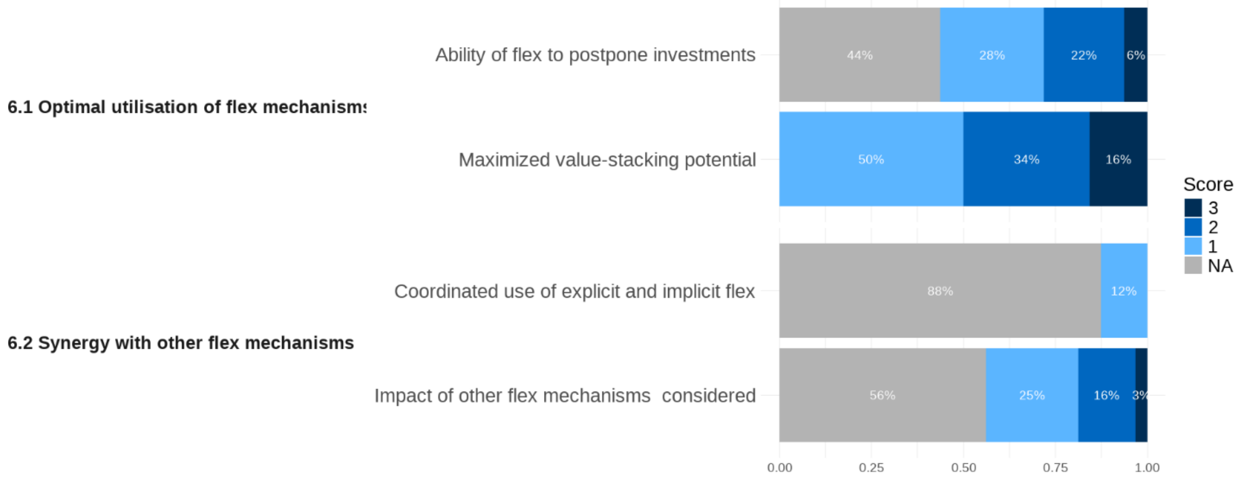


*Figure 3-7: Overview of LFM assessment for objective 6 efficient network operation (Source: VITO own figure).*

### 3.2.6.1 Optimal utilisation of flexibility mechanisms

*Ability of flexibility to postpone investments*

Almost half of the initiatives indicated that they currently do not have any information on this topic. For the ones with a low score, which includes nine initiatives, there is no standardised methodology for making trade-offs between network investments and procuring flexibility. Very often, no methodology is available because this estimation cannot be made without an estimate of the reliability of service delivery, expected price levels of flexibility, and volumes to expect in the future. The results from the ongoing pilots will provide valuable input for more accurate calculations. In some cases, although no methodology is in place, the maximum flexibility price is clear, as DSOs incur financial consequences linked to current TSO-DSO agreements and rules. In other cases, a methodology is currently under development. Among the initiatives that do have a methodology in place, there is typically a CBA approach used to compare grid investments with flexibility procurement, which helps define tender budgets and set bidding price limits. In some cases, the methodology is specified within the SO network development plan. Few initiatives have methodologies established at MS level through regulation. Seven initiatives reported that flexibility procurement is based on a trade-off with investment, but not sufficient flexibility is available. These received a medium score. The two initiatives with a high score can procure sufficient flexibility to cover their needs and they do this based on a trade-off with investment.

*Maximised value-stacking potential*

Value stacking can be achieved through enhanced market coordination. As such, the same scoring methodology applies as for the indicator *efficient market coordination* under the criterion of *economic efficiency*; A low score corresponds to 16 initiatives operating separate SO LFMs, a medium score applies to 11 initiatives using a sequential market approach, and a high score is assigned to 5 initiatives that have established a common market. Additional details on the scoring can be found in sections 3.2.3 and 3.2.4.

#### 3.2.6.2 Synergy with other flexibility mechanisms

*Coordinated use of explicit and implicit flexibility*

Overall, there is very limited attention given to the coordinated use of explicit and implicit flexibility within the studied LFM initiatives. A total of 28 initiatives reported this indicator as not applicable (NA), as no implicit flexibility mechanisms were in place. The other four initiatives received a low score, reflecting the absence of coordination, which may lead to negative impacts on FSPs or GUs. In these cases, the simultaneous implementation of a dynamic grid tariff and a LFM can result in conflicting signals. No initiative received a score higher than 1. Achieving a score of 2 would require that the impact of the LFM on grid tariffs is actively considered, such as through the implementation of a correction mechanism to align the two approaches. A score of 3 would signify a fully coordinated use of both implicit and explicit flexibility, thereby contributing to overall efficient network operation.

*Impact of other flexibility mechanisms considered*

For the second indicator, which assesses whether the impact of other flexibility mechanisms is considered, the overall scores are slightly better than for the first indicator on coordination between implicit and explicit flexibility. A similar scoring reasoning is applied as for the previous indicator. Eighteen initiatives reported this indicator as not applicable (NA), indicating that no relevant other flexibility mechanisms were in place. Score 1 was assigned to eight initiatives, where the mechanisms in place operate completely independently of one another. Score 2 was given to five initiatives, where some level of interaction exists, for example, grid users with an FCA are allowed to participate in the LFM. In some of these initiatives, the FCAs are arranged through the same platform used for the LFM, through a pre-defined sequence or priority. Score 3 reflects co-optimisation between the LFM, FCA, and potentially other flexibility mechanisms. Only one initiative achieved this score. This is a special case, as in this case, a secondary flexibility market has been developed where curtailment obligations can be traded between customers with a non-firm connection and those with a firm connection.

### *3.2.7 Objective 7: Consumer centricity*

For the objective **consumer centricity**, we have identified two indicators, *consumer engagement* and *limited uncertainty*. Figure 3-8 shows the distribution of scores across the LFM initiatives for the indicators linked to these criteria. On the topic of consumer engagement, there is considerable variation in scores across the different initiatives and indicators. However, the majority of initiatives do achieve at least a moderate score on the indicators related to limited uncertainty. From an FSP perspective, access to information is essential for assessing their business case. FSPs may need to make operational adjustments or invest in assets to provide flexibility services. When the future demand for flexibility and its corresponding value are unclear, making such decisions becomes significantly more difficult. This criterion, therefore, reflects a LT perspective. In the remainder of this subsection, each indicator will be discussed in more detail.

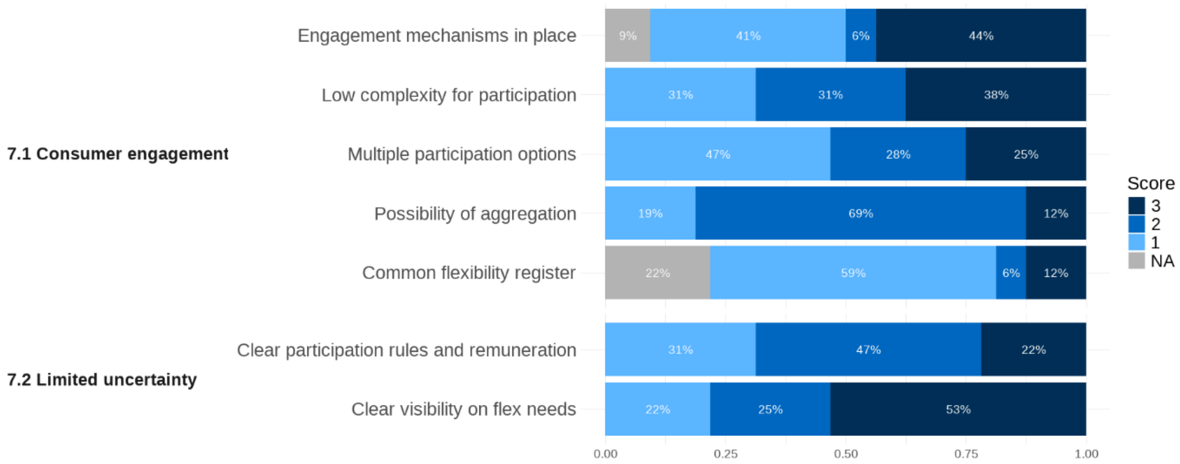


*Figure 3-8: Overview of LFM assessment for objective for objective 7 consumer centricity (Source: VITO own figure).*

#### 3.2.7.1 Consumer engagement

*Engagement mechanisms in place*

For the indicator assessing consumer engagement mechanisms, the level of development and implementation varies significantly across the studied initiatives. A total of thirteen initiatives do not yet have consumer engagement mechanisms in place. This is primarily because the initiative is still in a preparatory phase or because consumer engagement has not been a focus within the pilot setting. Score 2 was assigned to two initiatives, where consumer engagement is limited to existing FSPs. These initiatives conducted targeted engagement activities, such as site visits and direct FSP contact. Score 3 was awarded to fourteen initiatives that implemented consumer engagement strategies directed at all potential FSPs. A range of approaches and communication channels were used across these initiatives, including webinars, social media outreach, public information sessions, recruitment workshops, and the distribution of information sheets and tender documentation to prospective market participants. Additional measures include establishing dedicated teams to respond to questions and concerns and using both mass media and digital advertising to raise awareness and attract participants.

*Low complexity for participation*

The scores on the indicator assessing low complexity for participation are quite evenly distributed among the studied initiatives. Ten initiatives received a low score. In one of these, the participation process was notably complex, posing clear barriers for potential participants. The remaining initiatives in this category did not specifically address or mention the issue of participation complexity. Another ten initiatives were assigned a score of 2, reflecting that overall, the participation process for FSPs and flexibility assets was relatively straightforward. These initiatives typically featured easy registration procedures, simplified PQ steps, and clear rules for participation, making it easier for stakeholders to engage in the market. Twelve initiatives achieved a score of 3, indicating not only low complexity in the participation process but also the presence of additional supporting features and user interfaces. For example, some initiatives offered web-based applications for handling PQ, while one initiative provided a user interface on the FSP side that suggests suitable bids based on real-time SO needs. In certain cases, FSPs were also able to automate elements of their participation, such as automatically responding to DSO requests. Further, some initiatives enabled PQ at the aggregated pool level and supported bulk data uploads, as well as easy switching of individual units between aggregators.

*Multiple participation options*

For the indicator *multiple participation options,* the scores are also quite spread, with a larger portion of the initiatives receiving a low score. Almost half of the initiatives, fifteen in total, received a score of 1. These are separate SO LFMs with no coordination efforts and only limited possibilities for participants to take part in other markets. Nine initiatives received a score of 2. These include some degree of coordination, which enables value stacking, i.e. coordination of timing between different markets. Eight initiatives received a score of 3. These have implemented explicit measures to facilitate value stacking and cross-market participation. Examples include mechanisms such as freeing bids at specific points in time, allowing FSPs to define a minimum notice period for activation to allow for subsequent participation in other markets, automatic forwarding of bids across markets, and, in some cases, applying a common market setting.

*Possibility of aggregation*

For this indicator, the same scoring is applied as for the indicator *allowed and inclusive aggregation* as part of the criterion *minimised entry barriers*. As explained, in over 80% of the initiatives, i.e. those scoring 2 or 3, aggregation was allowed. Only a few initiatives have supportive measures like aggregated baselines, portfolio-level settlement, and dynamic portfolio adaptation, qualifying them for the highest score. For more information, we refer to section 3.2.2.

*Common flexibility register*

For the indicator common flexibility register, approaches differ across initiatives. Seven initiatives have no register in place yet. Nineteen received a score of 1, featuring a register at the level of the LFM, often provided by the market platform. Two initiatives scored 2, using a common register shared with at least one other market. Four initiatives received a score of 3, having established or initiated a common register at the MS level.

#### 3.2.7.2 Limited uncertainty

*Clear participation rules and remuneration*

For the indicator *clear participation rules and remuneration*, initiatives show varying levels of maturity. Ten initiatives received a score of 1, where participation rules are either unclear or still under development, and the expected remuneration is uncertain. In these cases, participation rules may be overly complex, and/or the business case evaluation is challenging due to a lack of information on the value of flexibility. Fifteen initiatives scored 2, reflecting clear participation rules, but BC estimation remains difficult for FSPs. These initiatives provide some support, such as bidding price limits, aggregated market outcome data, or insight on methodology used to compare flexibility with traditional grid investments. Additionally, in two cases local services are traded through bids in existing markets, which can help improve BC assessment for FSPs that are already active on these markets as it just constitutes an additional source of income. Seven initiatives achieved a score of 3, where participation rules are fully clear and FSPs can assess their business case. Supportive measures in these cases include fixed seasonal availability payments, transparency on market duration and expected activations, and SOs publishing procurement volumes and prices.

*Clear visibility on flex needs*

The scores for *visibility on flexibility needs* are generally positive across initiatives. A minority of seven initiatives received a score of 1, where no information is shared on expected future flexibility needs. Eight initiatives scored 2, providing aggregated, LT forecasts of flexibility needs. This information may be shared through congestion zone maps, details of ongoing tenders, or high-level needs outlined in NDPs. Seventeen initiatives achieved a score of 3, offering specific and regularly updated data on flexibility needs, often tied to precise locations. In addition to LT forecasts, SOs in these initiatives publish flexibility requirements for every market session and area, sometimes combined with activation probability, enabling more informed participation.

### *3.2.8 Objective 8: Stable market design*

For the final objective **stable market design**, we will assess four main criteria, i.e. *potential for standardisation, adaptability to changing market conditions, replicability and scalability,* and *interoperability.* Figure 3-9 shows the distribution of scores across the LFM initiatives for the indicators linked to these criteria. When examining the figure related to the indicator potential for standardisation, it becomes clear that products and PQ processes are mostly not yet standardised across initiatives. However, a greater number of initiatives do employ standardised baselining methods. The majority of LFM initiatives appear to be at least partially adaptable to changing market conditions, but there is insufficient data to realistically assess their replicability and scalability. Interoperability also appears to be rather limited across initiatives and platforms. In the remainder of this subsection, each indicator will be discussed in more detail.

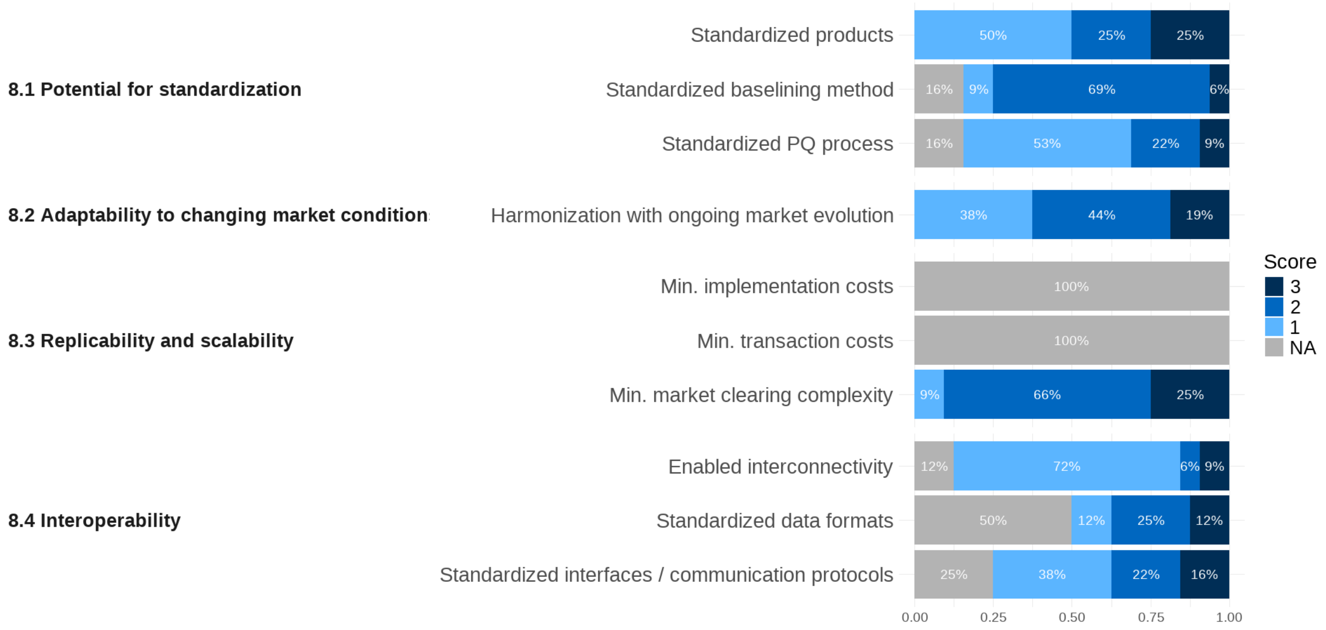


*Figure 3-9: Overview of LFM assessment for objective 8 stable market design (Source: VITO own figure).*

#### 3.2.8.1 Potential for standardisation

*Standardised products*

Sixteen initiatives received a score of 1, where the LFM products are tailored to the individual needs of the SO, resulting in limited standardisation. Eight initiatives scored 2, featuring LFM products shared among multiple SOs, for example, through joint use of the same product definitions or standardisation efforts at the MS level. Eight other initiatives achieved a score of 3, where the LFM product is aligned with existing market products, such as DA, ID, or balancing markets.

*Standardised baselining method*

A similar scoring is used as for the indicator *coordinated baselining procedures.* In most initiatives, there is some degree of coordination, i.e., a total of 22 initiatives received a score of 2, indicating that the baseline method is defined at the LFM level, but it follows a similar approach to those used in other markets, such as balancing. For more information, we refer to section 2.2.3.4

*Standardised PQ process*

The same scoring is used as for the indicator *coordinated PQ procedures*. Most initiatives demonstrate a low level of coordination in their PQ processes. More information can be found in section 2.2.3.1.

#### 3.2.8.2 Adaptability to changing market conditions

For this indicator, only one criterion was assessed: *harmonisation with ongoing market evolution*. Twelve initiatives received a score of 1, showing no harmonisation efforts, with market designs tailored primarily to local needs. This group includes one initiative testing a novel P2P concept within an innovation project, which is not yet considered business as usual, and another is testing a unique LFM with a floor-and-share mechanism and the use of operating envelopes. Fourteen initiatives scored 2, reflecting some efforts to future-proof their LFM design and enable market scaling. These efforts include harmonisation among DSOs at the national level, alignment with TSO balancing markets where possible, cross-country discussions, the use of the same platforms across different LFMs, and bid forwarding functionalities. Six initiatives achieved a score of 3, demonstrating advanced integration of LFMs into an overall, future-proof market architecture. This includes the use of coordination functionality that optimises different services for different actors across interconnected SO grids, as well as integration of bids for local services into existing markets.

#### 3.2.8.3 Replicability and scalability

For the criterion replicability and scalability, we identified three indicators, i.e., *minimised platform implementation costs, minimised transaction costs,* and *minimised market-clearing complexity.* For the first two indicators related to costs, there is a clear lack of information that could be provided by the LFM initiatives, as shown in Figure 3-9. In many cases, initiatives indicated that the data was either confidential, unavailable due to the fact that the LFM was still in a preparatory phase, or not representative of actual costs because the initiative is operating in a demonstration setting. As a result, we were unable to include these two parameters in our assessment.

*Minimised market-clearing complexity*

Most initiatives exhibit a medium to high level of *market-clearing complexity*, reflecting the varying degrees of sophistication in their market design. Three initiatives received a score of 1, indicating high complexity, often due to detailed network representation within the market, the use of complex bid structures, and/or the need for coordination across multiple markets. Twenty-one initiatives scored 2, reflecting medium complexity. These typically involve mechanisms such as ST procurement (CGA or continuous trading), sometimes combined with the use of impact factors or traffic light systems that can add complexity. Eight initiatives were assigned a score of 3, representing minimal complexity, generally limited to LT tenders with a small number of providers.

#### 3.2.8.4 Interoperability

*Enabled interconnectivity*

For this indicator, several aspects are relevant i.e. whether the LFM can effectively exchange data, coordinate actions, and/or enable value stacking with other markets. Overall, the LFM initiatives demonstrate limited interconnectivity. Twenty-three initiatives received a low score, indicating no interconnectivity, as the LFM operates as a standalone platform without any data exchange or coordination mechanisms. Four initiatives scored 2, reflecting partial interconnectivity, since some measures are in place, such as bid forwarding. Three initiatives achieved a score of 3, showing full interconnectivity, where the LFM is interoperable with other platforms, enabling real-time coordination and value stacking. These cases typically feature common market settings and initiatives with a coordination function that optimises across multiple markets.

*Standardised data formats*

For the indicator related to *standardisation of data formats*, the level of maturity across LFM initiatives varies significantly. Four initiatives received a score of 1, relying on proprietary or undocumented formats with no use of recognised standards. Eight initiatives scored 2, where some standardised formats are used, but without alignment to EU best practices. Four initiatives achieved a score of 3, demonstrating full adoption of open, recognised standards. Half of the initiatives did not provide any information.

*Standardised interfaces / communication protocols*

In terms of *standardised interfaces and communication protocols*, twelve initiatives scored 1, indicating no use of standard interfaces or protocols. Seven initiatives received a score of 2, having developed standard protocols either at the national level or using formats that are not yet widely recognised or still under development. Five initiatives reached a score of 3, successfully implementing accepted EU-level standard interfaces and communication protocols.

### *3.2.9 Conclusion*

In this chapter, we performed an in-depth assessment of the LFM initiatives using the assessment framework. A brief summary is provided of the main outcomes across the **eight objectives**.

- Most LFM initiatives showed moderate **transparency**, with clear rules and defined roles, though detailed market outcomes and flexibility values were sometimes limited due to complexity or confidentiality.
- **Non-discriminatory markets** were generally supported, especially through technology neutrality, aggregation, and simplified qualification, with opportunities to further align pricing and penalties with real-time conditions.
- Regarding **efficient markets**, most surveyed LFM initiatives aim to optimise socio-economic welfare, while integration of network constraints is still developing, liquidity is emerging, and mechanisms to address potential market gaming are gradually being implemented.
- **Integrated markets** show evolving coordination across TSOs, DSOs, and existing electricity markets, with some initiatives demonstrating joint clearing, dynamic grid-aware coordination, or harmonised participation.
- **Secure network operation** is progressing, with several initiatives incorporating network-aware clearing, dynamic grid checks, or baseline monitoring, while broader coordination across grids and validation of flexibility services continues to mature.
- **Efficient network operation** is currently an area of ongoing development, with some initiatives applying cost-benefit analyses or enabling value stacking, while methodologies to balance flexibility procurement with grid investment or coordinate between different flexibility mechanisms are being refined.
- **Consumer centricity** is moderate, with varying engagement levels, generally clear participation rules, transparent remuneration, aggregation options, and increasingly detailed visibility on flexibility needs, though multi-market participation and common registers remain in early stages.
- Finally, **stable market design** shows limited standardisation of products and PQ processes, with partial adaptability to changing market conditions.

Overall, the LFM initiatives are still in early stages of development, though some initiatives already feature advanced elements that support the realisation of the **eight objectives**.

This assessment will form the basis for the identification of key success features in Chapter 4, i.e. we will identify the market design choices which contributed to having high scores on the different proposed indicators, linked to the criteria, while considering the local context in which the LFM initiatives are situated. In particular we will then identify which characteristics of the market, design and governance structure can explain the higher or lower scores on the assessment criteria.

# 4 Key success features

The detailed analysis and evaluation of the LFM initiatives in chapter 3 enable the identification and extraction of key driving factors and success features, providing lessons learned that can support the setup, evolution, and scaling of LFMs. The success and challenges faced by different LFMs can be specific to the context in which the LFM is set-up, so one-size-fits-all success recommendations may not always be suitable or adequate. The success features presented aim to help draw general guidelines, which new and existing initiatives can then use in their specific context.

The key success features are extracted based on the assessment of the LFMs introduced and analysed in chapter3.

Most of the underlying context factors (such as characteristics of the energy system, need to be addressed, and available flexibility) that can impact certain market design decisions can be linked to the maturity of the market. In the analysis, we therefore distinguish between ST and medium-term features. In addition, for the ST features, we distinguish between no-regret features and transitional features. In total, we therefore distinguish three types of features:

- **ST no-regret features:** The ST no-regret features consist of features that are generally essential and recommended for integration in LFM initiatives, even at the time of their initial setup and will continue to be relevant as the LFMs mature.
- **ST transitional features:** In the initial development phase of setting up an LFM, SOs can aim for non-complex designs with the primary goal of setting up the market, encouraging the engagement and the simple participation of FSPs, and building experience for all partners involved, before moving to more mature and complex stages. As such, ST features could be seen as immediate steps, allowing the initiation of an LFM with limited complexity to gain experience and increase market engagement and participation (and eventually, liquidity), when going for more complex design can prove to be arduous or prohibitive.
- **Medium-term target features**[19]**:** Medium-term features are ones that reflect the target design that could be sought after the initial development phases of the LFM initiative, i.e., after the accumulation of additional experience and reaching an improved maturity level, at which point the objective of the initiatives can be guided towards more efficient and optimised implementations and market practices (which typically entail additional complexity). The evolution toward the target features involves a progression from the development phase to mature LFMs, and ultimately to harmonised markets that are fully integrated into the overall market setting.

It is not straightforward to assign exact timeframes to this process. Based on accumulated knowledge and experience across EU countries, and considering the inputs received as part of the study, it is assumed that the ST development phase could last up to two to three years when initiating an LFM, progressively moving to a mature LFM within three to five years, and further transitioning to the target model - a harmonised LFM - within five to eight years, depending on the circumstances. These timeframes are, however, indicative. Member States that have already established markets may progress more rapidly, whereas those with less experience, less favourable initial conditions, or more

[19] It should also be noted that, for certain local issues, it may not be necessary or even possible to transition to the target market design. For instance, if there is insufficient liquidity within the targeted area, it will not be feasible to move to the LT target model. Moreover, in some cases, a more advanced market design may not be needed, for example, when the flexibility need is solely located at the interface flow between system operators (SOs), a detailed representation of the underlying grid needs may be unnecessary, especially if the grid has sufficient spare capacity.

complex contexts may require additional time. It should also be noted that incremental improvements to the markets can always be made, in line with evolving innovations and insights.

The success features are classified according to the main categories of the classification structure in Section 2.2. For each category the three types of key success features (ST no-regret, ST transitional, and MT target features) will be explained and summarized in a figure in the remainder of this chapter. In addition, some needs for further innovation are identified for the different topics, which will facilitate the evolution towards the target LFM design.

Finally, the compliance of identified success features is checked against (upcoming) EU regulation, in particular the current version of the NC DR [10]. It should be noted that, unless otherwise specified in this chapter, any reference to the current draft NC DR pertains to reference [10]. We distinguish three levels of compliance: ✔ complete compliance, ± medium compliance, ✕ no compliance.

## *4.1 Product design*

Figure 4-1 shows a summary of the three types of key success features for the product design of LFMs, as well as the areas that require further innovation. These will be further described in more detail below the picture.

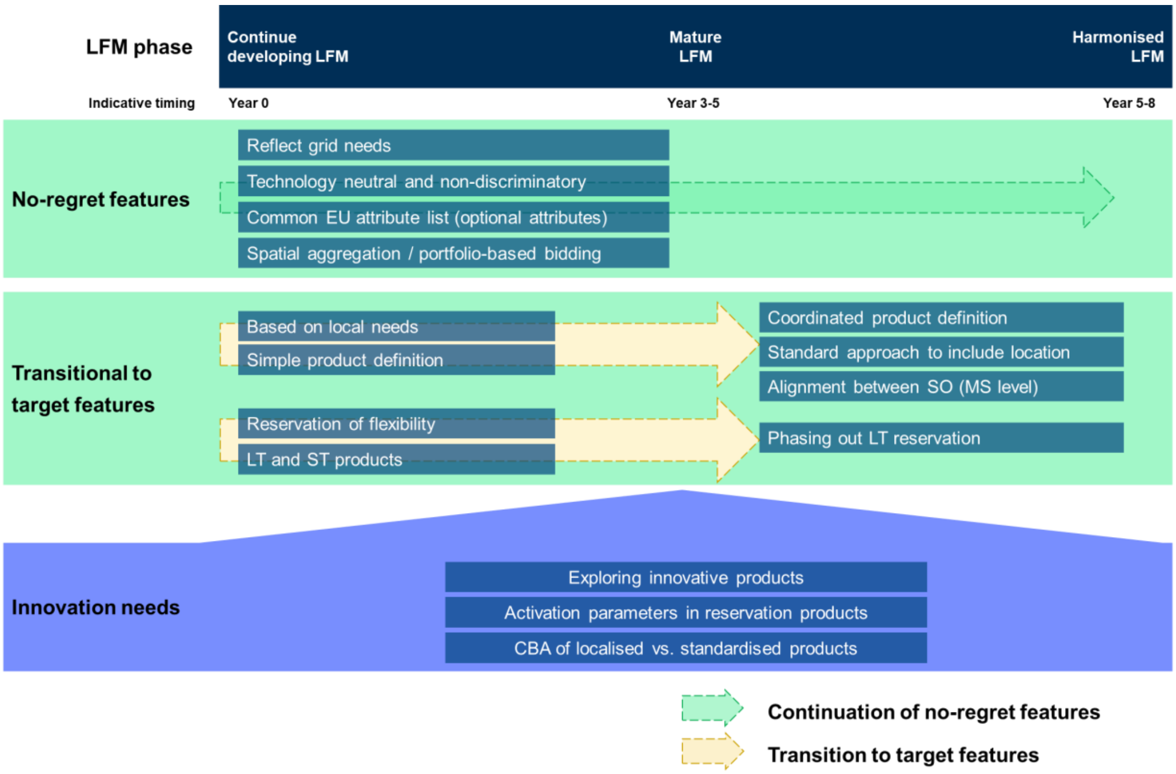


*Figure 4-1: Key success features product design (Source: VITO own figure).*

An adequate design of the products traded in an LFM is indispensable for ensuring that (i) the grid flexibility needs are adequately met, and (ii) the design parameters support the participation potential of available technologies and FSPs. Thus, the success of an LFM initiative hinges upon a suitable set of product definitions, rendering such fundamental dimensions into ST no-regret features. Indeed, in addition to designing the products to reliably source flexibility when and where it is needed, product definition should be non-discriminatory from a technology perspective, thus supporting the participation of different technologies. As part of product definition processes, it would be recommended to discuss upfront with potential FSPs on specific concerns and insights they have to **maximise local participation**, ensuring grid needs can be properly reflected in the product design. Nonetheless, some flexibility service needs necessitate the application of technical product requirements (e.g., activation time, ramp-up needs, availability requirements) that may not be readily met by a single technology or a type of users. In this respect, **aggregation** can play a key role in allowing a collective set of assets to meet the product (and service) requirements [16]. As such, it is considered to be an ST no-regret option to fundamentally aim for **technology neutrality** when defining products, thus not explicitly (directly or indirectly) excluding different technologies, and allowing spatial aggregation and portfolio bidding, to the extent that the grid constraints (and flexibility needs) permit, to decrease potential entry barriers. To build on previously organised initiatives and running markets, following a **common list of (EU) product attributes** would help the fast-track setup of new LFMs, increase comparability of products for local services and facilitate the participation potential of FSPs, by streamlining the product definition, thus rendering this aspect also a no-regret feature. Such an attribute list could be extracted from the current balancing product attributes. We, however, would like to emphasise that these attributes should be optional, leaving freedom to the procuring SOs to define more simplified products for local services by omitting certain proposed attributes that are not necessary to reliably deliver the local service.

In the initial development phase of an LFM initiative, some ST features can be proposed. During this phase, product definition choices can be tailored to the **local context** (such as specific grid needs or the requirements of local FSPs), at instances leading to **simpler product definitions** that primarily encourage FSP participation. The goal at this stage is to initiate market activity, with limited emphasis on aligning product requirements with those of other LFMs or electricity markets, or on enabling value stacking and market coordination. As such, these features are best understood as ST success factors rather than MT design principles. To improve initial liquidity and increase the potential for the SO to reliably and continuously procure its flexibility needs through the established LFM, **reservation requirements** can be added at initial stages, but while always allowing free bidding at activation stages, thus preventing barriers for technologies that face challenges with (LT) reservation/availability guarantees (such as renewables). Such features along with allowing a **mix of LT and ST products**, are ST features that support FSP participation as well as the reliable delivery of flexibility to the SO.

In the MT, the harmonisation of product definitions plays an important role in enabling TSO-DSO/DSO-DSO coordination, supporting the FSPs' participation in multiple markets (independently, or through bid forwarding), thus also empowering the maximisation of value-stacking potential. As such, MT target features can tend towards **coordinated product definition** with existing markets and/or central needs, encouraging a harmonisation of the products to the extent possible (e.g., relying on a list of potential attributes at EU levels, and a standardised set of products at MS level), to facilitate the use of flexibility for multiple services. In the MT, we expect a limited set of stable standardised local products **aligned between all SOs at MS level**. To better associate the offered flexibility with the grid needs and constraints, locational grid aspects are essential. To enable the use of flexibility for different services (outside the scope of one particular LFM) while safeguarding the grid to which such flexibility is connected, a **standardised approach for the inclusion of locational parameters** in the product definition constitutes, hence, a MT target feature. This recommendation extends beyond the product definition for local services, as a standardised approach to include local information should be used for all wholesale electricity market products. While in initial stages, reservation requirements can be added, in the MT, and on the condition that adequate liquidity levels are achieved, the need for (LT) **flexibility reservation can be mitigated and gradually phased out**, relying more on ST capacity and energy products, if the nature of the flexibility service allows it.
In

In terms of innovation needs, experimenting with **innovative products** such as capacity-limit type of products to avoid baselining challenges, or products that allow users to define some parameters/constraints (e.g., maximum number of activations, time between activations, duration of activation), while the product parameters that specify the allowable limits thereof are helpful to analyse their usefulness. Product types that prove to be successful can then be further expanded in the long term. An analysis of the adequacy of such flexible parameters as part of the product design, and how the market-clearing algorithm can accommodate and combine different product types, is an important topic for further study. Finally, striving for a coordinated product definition may come at an increased complexity cost for the SO and to the participating FSPs if the product requirements become too stringent. As such, a **cost-benefit analysis at MS level, comparing localised and standardised product design** options across services is a question that warrants additional research.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-1).

*Table 4-1: Elements covered in the NC DR [10] on product design - Compliance check.*

| Regulatory check - Product design | |
|---|---|
| Common EU list of product attributes | ± |
| Strive to use existing products (from DA or ID markets or balancing products) | ± |
| Requirement for standardisation at national level (list of local products at MS level) | ✔ |
| Standardised use of geographical / topological information about location | ± |

Article 38 of the draft NC DR provides a list of product attributes for both AP and RP products, according to which the product requirements for each congestion management product and voltage control product shall be determined. This corresponds partly to our key success features, but instead of using a minimum list we would propose to use a list of optional attributes. Certain attributes, which have been defined in this article (e.g. ramping period, FAT, deactivation time), might not be required for local services. In the current version of the NC DR definitions of the attributes are not provided, but it would be useful if they would also be available at EU level.

According to Article 39 of the draft NC DR, SOs shall strive to use existing products from day-ahead, intraday, or balancing markets for congestion management or voltage control. Furthermore, the product definition should facilitate the effective use of local products to meet the needs of multiple SOs. One of our MT key success features is also to evolve toward more coordinated product definitions. However, before moving in that direction, a CBA at the MS level is proposed to compare localised versus more standardised product design approaches across services. There is, therefore, partial alignment between the NC DR and our identified key success feature.

The same article also specifies that a list of all congestion management and voltage control products to be used by the SOs shall be included in the national TC for service providers. This corresponds well to our recommendation to have, in the MT, a limited set of stable and standardised local products at MS level. This is further supported by article 16, which requires the development of a national table of equivalences with an overview of the product requirements per attribute of all balancing and local products with an identification of equivalences per attribute between the product requirements of the different products.

Article 33 of the NC DR specifies that all procuring SOs within one MS shall use a standardised approach to the geographical or topological information related to the location of the metering or connection point in the system. In addition, "location" is also listed as a product attribute in article 38. In our view, this requirement could be extended to all wholesale energy and balancing markets, i.e. by proposing an overall standardised approach to include location in all product definitions across all markets. Since balancing, ID, and DA markets are already (partly) traded via European platforms, we believe a standardised approach at EU level should be introduced.

## *4.2 Market design*

We next explore the key success features – no-regret, ST, and MT – for the different market design dimensions.

### *4.2.1 Prequalification*

Different forms of PQ (SP PQ/product qualification, and grid PQ) are considered to ensure that flexibility can be reliably delivered when it is procured. The goal of ensuring the reliable delivery of flexibility through PQ faces the challenge of not leading to overly complex PQ schemes that either unnecessarily filter out available flexibility or discourage the participation of FSPs. Striking that balance is of key importance for the success of LFM initiatives. In the remainder of this section we will first present and explain the key success features for FSP and product qualification and afterwards we will revert to grid PQ and grid checks.

#### 4.2.1.1 Service provider prequalification and product qualification

Figure 4-2 shows a summary of key success features for SP PQ and product qualification. A more detailed explanation is given below the picture.

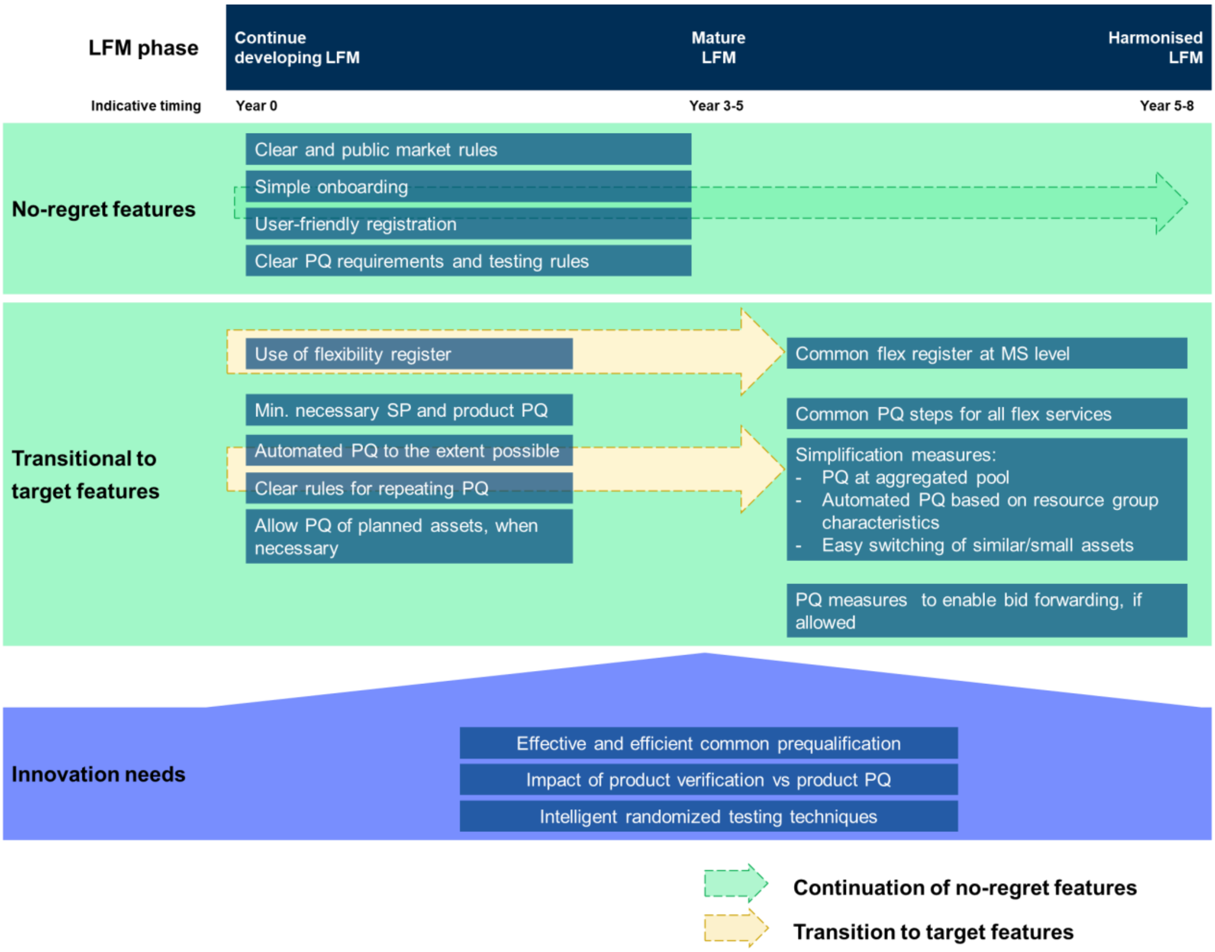


*Figure 4-2: Key success features for SP and product qualification (Source: VITO own figure).*

A key no-regret feature of an effective SP and product qualification process is transparency. Clear, publicly available PQ rules are essential to ensure that SPs fully understand the prerequisites for participating in an LFM and potential reasons for disqualification. To encourage broader participation, the onboarding and registration process should be simple and user-friendly. Reducing the administrative burden lowers the barrier to entry for new participants. Clear and consistent testing procedures are also crucial. These ensure that PQ outcomes are trusted and accepted by FSPs, thereby reinforcing confidence in the market framework.

In the initial phases of LFM, five ST design features for PQ are identified. First, beyond transparency and simplicity, the implementation of a flexibility register represents an important element of an LFM. This register collects information on the flexible assets of SPs, not only enabling the SO to assess whether their flexibility needs can be met through the market, but also providing a way to simplify and streamline the market participation process of SPs and the PQ mechanism, increasing trust in the market by enabling auditability and dispute resolution. Flexibility registers can also have an extended functionality in terms of flexibility forecasting and providing extended visibility for the SOs on the status of their grids given the available set of flexibility resources. Second, the condition and PQ requirements for SPs and the products can be limited only to what is strictly necessary, thus reducing entry barriers and administrative burden. Thus, these requirements can initially be tailored for the specific products that are offered in the market and can be gradually refined and extended as the product portfolio grows, while also considering previous PQ steps that the participating resources have gone through. Furthermore, wherever feasible, the PQ process should be automated to maximise efficiency and minimise manual intervention, a feature that can potentially be supported as part of the set-up of a flexibility register. Automation reduces the potential for human error and speeds up processing times. Additionally, it is equally important to define and communicate the conditions under which PQ must be repeated, when new flexibility resources are added, or in the case of multiple (subsequent) flexibility market participations. This includes specifying how the process will be conducted and whether any simplified procedures apply. If such simplifications exist, they must be made explicit and accessible to all stakeholders. Finally, if appropriate, PQ can also be allowed to be done to assets that are still in the planning phase, so that their participation can be sped up once they are connected to the grid.

In the MT, several key design features are recommended to enhance the effectiveness and scalability of product and SP PQ in LFMs. Establishing a common flexibility register at the MS level is essential for (i) facilitating effective coordinated flexibility procurement among SOs, as well as (ii) reducing the burden of repeated PQ for FSPs, as such improving efficiency, and reducing duplication efforts. Furthermore, harmonised PQ steps and approaches for all services at MS level will reduce inefficiencies and administrative burdens without creating barriers for the development of LFMs. Some simplification measures might also be incorporated while ensuring that all FSPs and/or flexible assets are prequalified on the same basis. For example, PQ can be carried out at aggregated pool level, supported by pool-level testing, automated PQ can be performed based on resource group characteristics, and the flexibility to switch similar or small assets within a portfolio can be enabled. Finally, PQ measures can be adjusted to support the possibility of bid forwarding, if allowed, wherein PQ is carried out in a coordinated manner between different flexibility markets, supporting value stacking for FSPs and increasing the attractiveness and efficiency of flexibility markets.

In terms of innovation needs linked to PQ, it should be noted that the recommended MT target feature of harmonising PQ steps and approaches for all services at MS level, is an effort that can face challenges when the nature of the technical requirements of different services diverges, rendering harmonisation efforts difficult. As such, devising a strategy for which PQ steps can be harmonised, and determining the services that can have an effective and efficient joint SP/product qualification, reliably meeting the services' requirements without inducing unnecessary barriers for FSP participation, is an area in which further analysis would be required especially taking the MS context into account. Furthermore, advanced testing techniques, such as intelligent randomised tests – through which SOs carry out random PQ tests of available resources, to ensure their PQ status is maintained – might also be considered in the MT to replace excess PQ at the time of market entry, although these measures require further analysis, for devising effective and efficient randomised testing and for investigating their effectiveness and efficiency. Finally, further analysis is also still needed to understand the impact of product verification vs product PQ and the advantages and disadvantages of both approaches.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-2).

*Table 4-2: Elements covered in the NC DR [10] on SP PQ and product qualification - Compliance check*

| **Regulatory check – SP prequalification and product qualification** | |
|---|---|
| Use of a 'Flexibility information system' with a single and common access point at MS level. | ✔ |
| Product PQ as simple as possible (limited to technically necessary level) and strives to minimise and standardise the different steps across services, when possible. | ✔ |
| Avoid unnecessary duplications in qualification processes. | ✔ |
| Simplify the product PQ for small controllable units. | ✔ |
| Product verification as default for products for local services. | ✘ |

Similarly, as we advocate for the use of a flexibility register, the draft NC DR also requires the use of a so-called flexibility information system to record, as a minimum, information on SP qualification, product qualification, and grid PQ of service providing units and groups. The NC DR distinguishes between an 'SP module' collecting data about service providers, service providing groups, service providing units and system users and a 'CU module' collecting data about controllable units. More specifically, article 17 of the draft NC DR, mentions that any market participant who applies to qualify as an SP shall register all relevant data necessary for its qualification and the procuring SO shall update the qualification status of the service provider in the relevant SP module. In addition, following article 18 of the draft NC DR, before a service provider applies for product PQ or product verification, the service provider, on behalf of the relevant system user(s), shall ensure that the data of the CUs are registered in the relevant CU module. Our study as well as the draft NC DR propose to use a common flexibility register (or common flexibility information system) at the level of the MS (article 18 draft NC DR) with a single and common access point. The management structure of the flexibility information system is to be defined in the National terms and conditions (article 24).

The NC DR also supports the idea of having simplifying measures for qualification processes where possible, by limiting the product qualification requirements to the technically necessary level, lowering the administrative burden and avoiding duplication in the qualification processes and steps where possible. Article 17 of the draft NC DR mentions that a simplified SP qualification process should be followed when a market participant is already qualified for at least one balancing or local product. Article 20 further specifies simplified product PQ should be used in the case of pooling of small controllable units or controllable units that are identical to controllable units being part of other qualified pools. In this case, an activation test, if required, may be performed on a limited number of controllable units.

The draft NC DR proposes the use of product verification as an alternative to product PQ when a service provider applies for congestion management or voltage control products (Article 19). As previously noted, the LFM analysis and assessment indicate that there is currently limited experience with the impact and practical implementation of product verification compared to PQ. Therefore, further analysis and experience sharing on this topic is advised.

#### 4.2.1.2 Grid prequalification

Figure 4-3 presents a summary of the three categories of key success features for grid PQ and grid checks. Each category will be described in more detail below the figure.

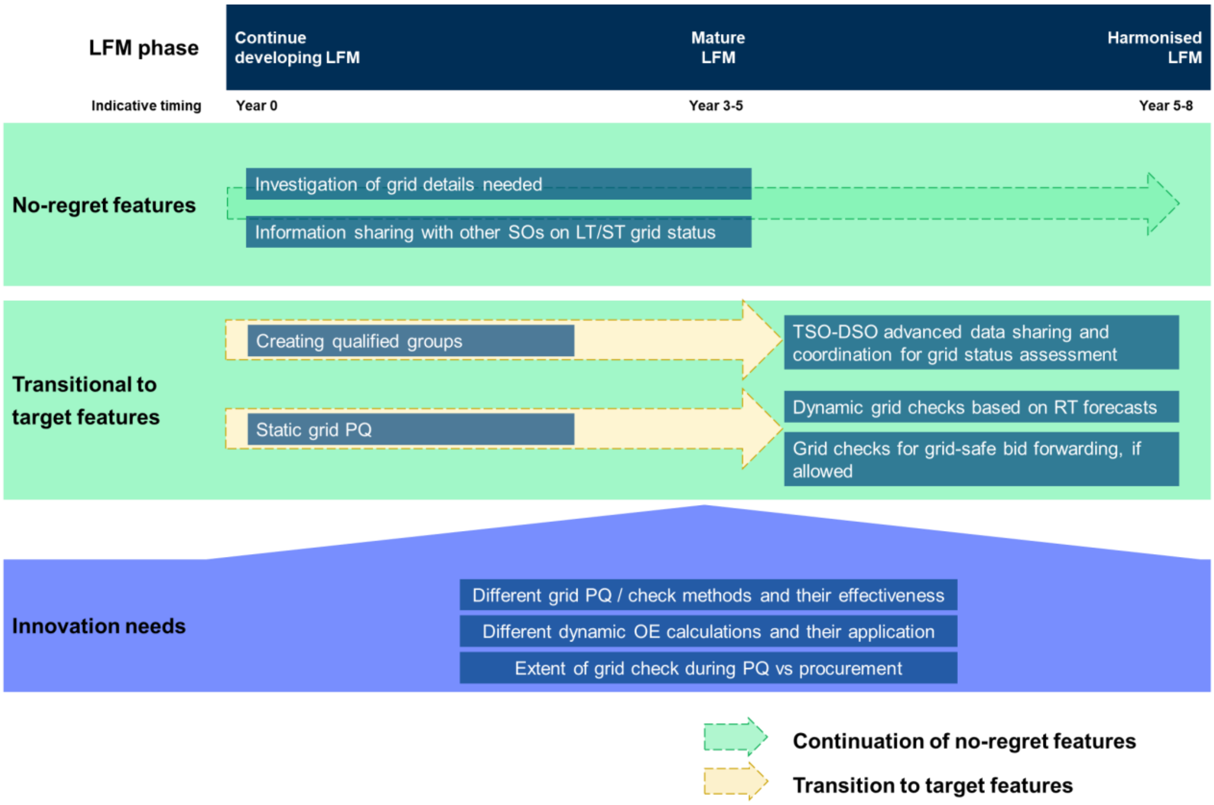


Figure 4-3: Key success features grid PQ (Source: VITO own figure).

In terms of grid PQ, as a first step and no-regret design feature, it is crucial to investigate the appropriate level of grid details required for performing grid checks during the PQ stage. This ensures that the PQ process is both efficient and sufficiently accurate for assessing the grid impact. In addition, effective sharing of information between all impacted SOs is essential, to ensure that when flexibility is activated by an SO outside its area of control, that this activation is safe for the grid to which the flexibility is connected. This should cover not only LT grid status but also more immediate, ST grid constraints. Such coordination enhances situational awareness and supports reliable decision making and operation across different system levels.

In the ST, a design feature that can support early market development is the creation of qualified groups, in which minor changes, such as the replacement or adjustment of some assets, do not trigger the need for a new PQ. This can further simplify market participation. Secondly, static grid PQ can be acceptable if proven to be safe for the grid. Furthermore, at this stage, grid PQ can be done with limited complexity, allowing for a manageable starting point while gaining operational experience.

In the MT, or earlier whenever possible, advanced data sharing and coordination between TSOs and DSOs in assessing their respective grid states will be critical for enhancing the efficiency and effectiveness of LFMs. Furthermore, grid PQ should evolve towards more granular and dynamic grid checks, leveraging near real-time forecasts and a better network representation, thus improving the efficacy of the PQ process (i.e., ensuring grid safety) while also ensuring its efficiency (i.e., avoiding unnecessary disqualification that can result from static LT worst-case-scenario-based grid PQ measures). Such checks may involve the use of linear or non-linear power flow models, the computation of operating envelopes at the PQ stage to filter or prune bids, and the replacement of static rules with dynamic ones that reflect the most current grid conditions. Finally, enhanced grid assessments can support grid-safe bid forwarding, if permitted, enabling flexibility to be optimally utilised across different market layers.

However, in terms of innovation needs, before such enhanced grid assessments can take place, we note that further analysis on the effectiveness of these more advanced grid PQ methods, such as dynamic operating envelopes, and network models, is needed, taking into account the practicality of their implementations, especially when considering limited (or not frequent enough) metering data and limited visibility of certain parts of the grid such as the LV grid. In addition, it is also important to assess the implications of using varying levels of grid detail at the PQ stage versus the procurement stage, as this impact analysis will help guide the future evolution of the grid PQ process.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-3).

*Table 4-3: Elements covered in the NC DR [10] on grid PQ - Compliance check*

| Regulatory check – Grid prequalification | |
|---|---|
| Connecting and impacted SOs have the right to perform grid PQ and set (or update) temporary limits. | ✔ |
| Each SO procuring local services from flexible assets connected to other SOs' grids should respect applicable grid PQ status and temporary limits. | ✔ |

In the current study, we distinguish between static grid PQ and more dynamic grid checks. Similarly, the draft NC DR differentiates between grid PQ and ST procedures to set temporary limits. It further emphasises that SOs should coordinate these two mechanisms and avoid imposing potentially excessive or unnecessary restrictions through grid PQ. Additionally, the draft NC DR states that each SO is responsible for addressing physical congestion and voltage issues within its own system and may procure local services from flexible units connected to the systems of other SOs. However, such solutions must respect the aforementioned grid PQ status as well as the temporary limits, in accordance with Article 48. There is thus a good fit between our key success features and the mechanisms proposed in the current NC DR related to Grid PQ.

### *4.2.2 Procurement*

Figure 4-4 provides an overview of the key success features related to the procurement phase of LFMs. The three types of key success features will be further explained below the figure.

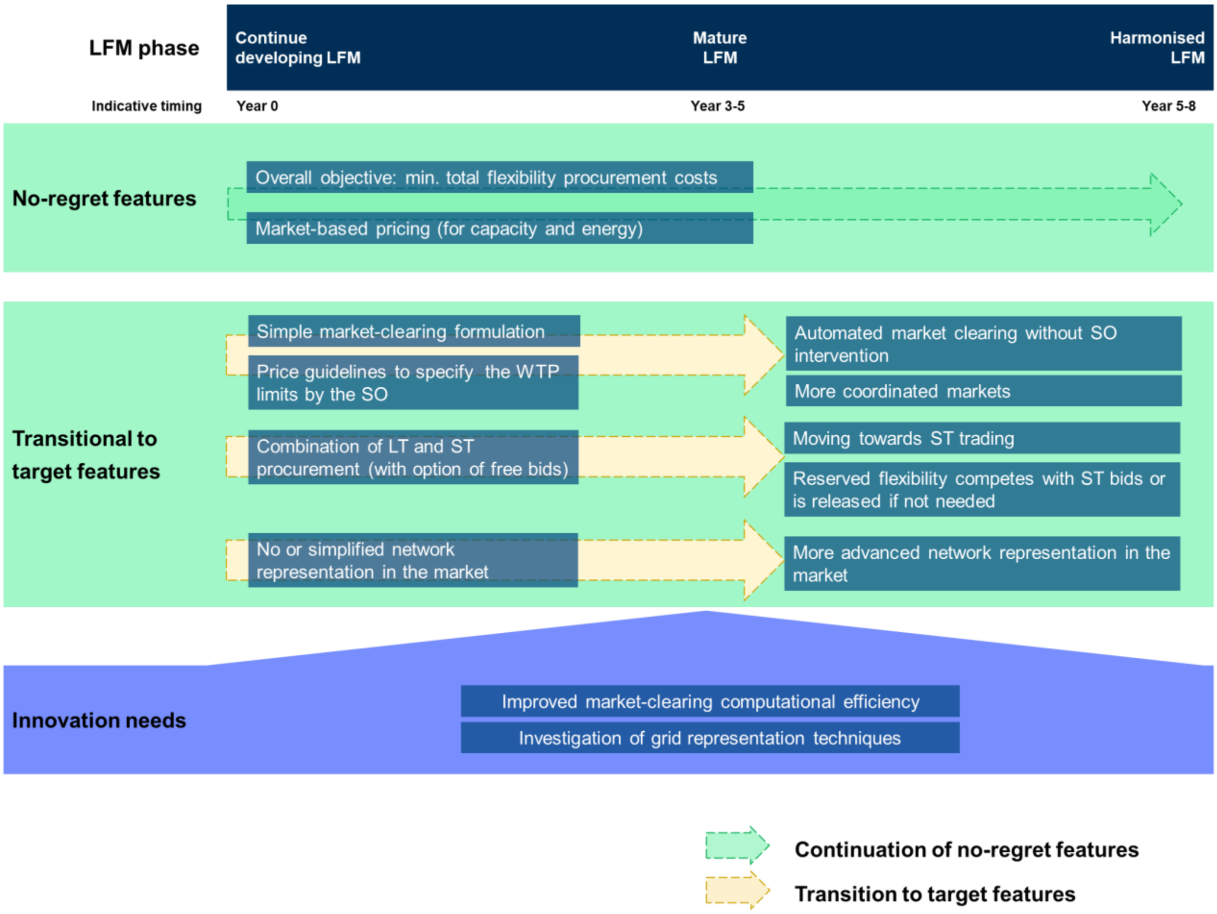


*Figure 4-4: Key success features procurement (Source: VITO own figure).*

For the procurement process, an essential no-regret design feature is to ensure that the overall market objective is to minimise the total flexibility procurement costs (i.e., maximising social welfare). To support this objective, all pricing, whether for capacity or energy procurement, should be determined through market-based mechanisms, avoiding the use of fixed or predetermined prices. Market-based pricing fosters competition, reflects the true value of flexibility, and encourages innovation and investment from FSPs.

In the ST, simpler procurement methods can be acceptable, allowing stakeholders to gain experience while minimising implementation complexity. This may include market processes that are not fully automated, a simple market-clearing formulation, and the use of a simplified network representation, such as market areas based on network information or the use of impact factors to approximate the impacts of different flexibility bids on grid constraints. Note that the network representation to be used also highly depends on the type and location of the flexibility needs that will be solved. In initial market stages, liquidity can be relatively low, leading to market power and inflated prices. In the meantime, the SO can still have other alternatives for procuring flexibility to solve the grid needs. As such, price indications/bidding price limitations can be included in the first stages of the market to reflect the maximum levels an SO is willing to pay. Additionally, the market can be a combination of LT capacity reservation with ST energy trading, as also explained in section 4.1. This setup would further benefit from the option for free bids in the ST market, allowing participants to respond dynamically to evolving grid needs. Besides auction-based markets, continuous markets could be set up in which flexibility is continuously procured by the SO as needed.

In the MT, LFMs should evolve towards a high degree of automation, coordination, and market sophistication, which can be achieved using the introduced optimisation-based formulations and market clearing. ST procurement processes should be fully automated, enabling market clearing without the intervention of SOs. Meanwhile, manual selection for LT procurement, such as tenders, can remain acceptable provided that it leads to optimal and consistent market results (i.e., if the resulting optimisation problem can be manually solved). Furthermore, LFMs should progress towards coordinated or common market schemes to leverage synergies with existing markets, to maximise liquidity, and, ultimately, to reduce the overall procurement costs. More information on success features linked to market coordination will be given in section 4.3.1. In addition, the market procurement should move toward ST trading mechanisms, e.g., by combining closed-gate auctions closer to real time, intraday continuous markets, or iterative auctions, offering greater responsiveness and efficiency. If LT flexibility reservations for local services are still necessary, two principles should be followed: (i) reserved flexibility must compete with free bids where applicable to ensure market fairness, and (ii) mechanisms should be established to allow unused reserved flexibility to be redeployed for other services, maximising resource efficiency. Finally, the market should also adopt more advanced network representations within the market-clearing formulation to better reflect grid constraints and enhance the accuracy of dispatch decisions.

In this regard, further studies are needed. It is important to investigate how to improve and find an acceptable trade-off between market-clearing computational efficiency and accuracy under complex formulation. This includes investigating grid representation techniques that safeguard the grid while avoiding a detailed network representation, which necessitates advanced network model information sharing.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-4).

*Table 4-4: Elements covered in the NC DR [10] on Procurement - Compliance check*

| **Regulatory check – Procurement** | |
|---|---|
| Procuring local services in accordance with a market-based mechanism. | ✓ |
| Pricing mechanism for local services shall ensure cost efficient activation of bids. | ✓ |
| The pricing mechanism shall allow for predetermined prices subject to an assessment of the economic efficiency. | ± |
| The respective energy bids of capacity products shall be subject to competition with other non-contracted energy bids. | ✓ |

The draft NC DR states that local services should be procured through a market-based mechanism. It provides a definition of market-based procurement as a process in which either the selection of service providers or the activation of the service is based on a bidding process (article 2). Article 35 further specifies that the pricing mechanism for the market-based procurement of local services must ensure the cost-efficient activation of bids. Additionally, the article, however, allows for predetermined prices to be included in offers for the availability and/or activation of resources contracted in advance, provided that such arrangements undergo an assessment of economic efficiency. However, this latter provision does not fully align with our key success feature, which calls for prices to be market-based, both for capacity and energy procurement, in order to avoid fixed or predetermined pricing.

According to Article 32 of the NC DR, when local services for active power are procured as capacity products, the activation of energy bids from the contracted resources shall be subject to competition with other available non-contracted energy bids in the respective market, provided such an activation market is established. This provision aligns well with one of our key success features: ensuring competition between LT reserved flexibility and ST free bids or other ST energy products available within LFM.

### *4.2.3 Activation*

The way activation is carried out as part of an LFM has a direct impact on the reliable delivery of the procured flexibility and is, thus, of significant importance. Figure 4-5 shows the key success features related to activation.

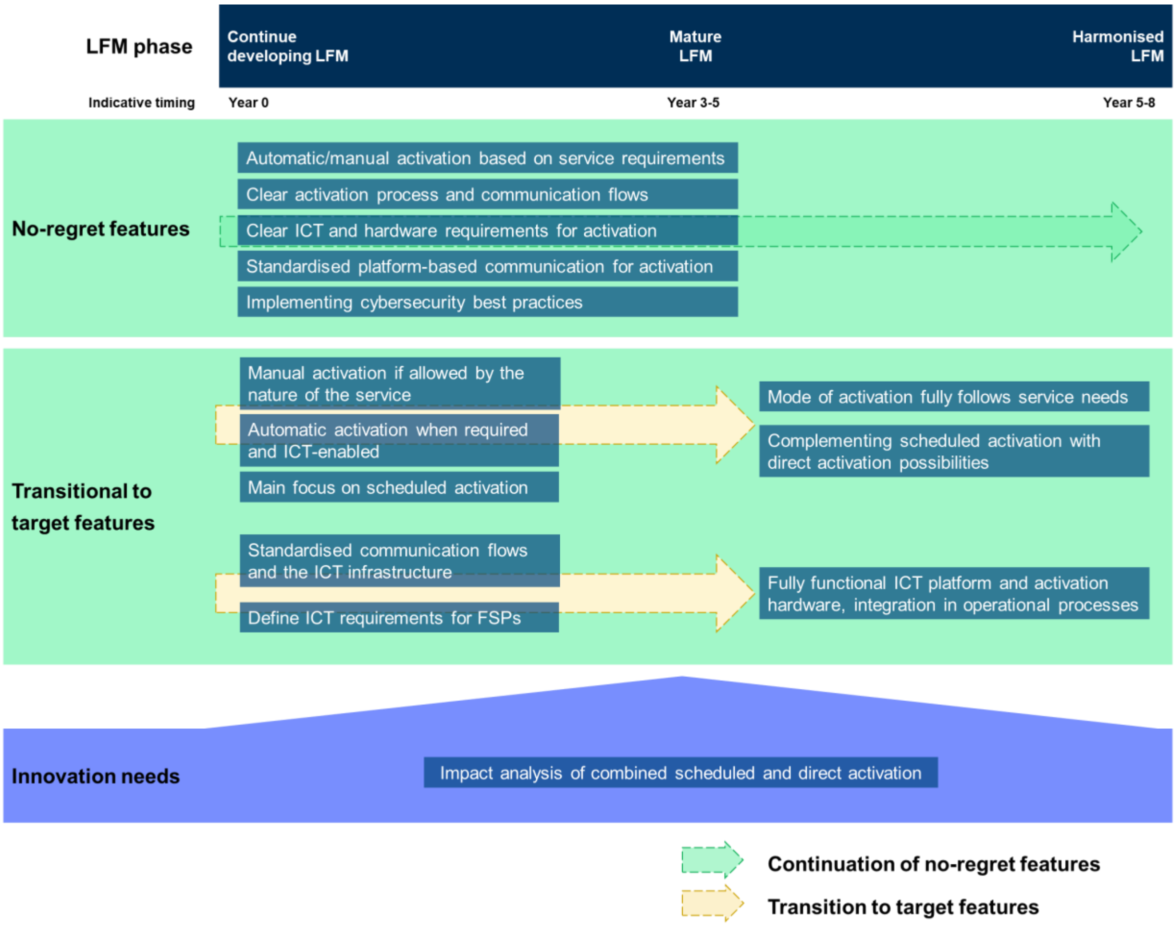


*Figure 4-5: Key success features activation (Source: VITO own figure).*

A first no-regret feature, recommended in terms of activation, is to establish the type of activation based on service requirements. That is: activation time and requirements are directly linked to the service procured and are part of the product specification. The choice of automatic or manual mode of activation depends therefore on the nature of the service procured, its activation frequency, and its closeness to real time operation. For services procured well ahead of time, with sufficient preparation period, ramping period, and activation time, manual activation can still be employed (as it requires less hardware and ICT support at the FSP’s side), while for faster more granular services, direct control actions by the SO using an automatic mode of activation would be necessary. It is, hence, a no-regret success feature to classify the services and activation needs appropriately to identify the best mode of activation to be deployed. As different modes of activation also require appropriate communication infrastructure and placement of necessary hardware (for enabling automatic control), the choice must also consider the feasibility of the approach and the requirements to be placed on potential FSPs. Standard forms of activation (e.g., platform-based communication rather than by phone or e-mail), whether automatic or manual, and clear communication flows, are a no-regret feature, as they ensure efficient and reliable communication and delivery of activation signals. Here, taking adequate cybersecurity measures to ensure the reliability and integrity of the communicated signals is of prime importance, and is a no-regret feature.

On the ST, especially in situations where the service allows manual activation and where possibility of direct control is in any case limited, a manual approach is to be adopted, as it also puts fewer requirements on the FSPs. If the nature of the service allows manual activation, this mode can also be carried out in the LT. In addition, scheduled activation mode can be more easily accommodated by FSPs as compared to direct activation and can thus be the main focus in the initial phases of the LFM. For services requiring direct control, and for local settings in which the required ICT infrastructure is already in place, automatic activation can be implemented even in the ST. Setting up standardised communication flows and the ICT infrastructure focusing on the basic required features (as a first step) is also essential in the initial steps of the LFM initiative, as it allows all parties to gain experience with the process and enable testing activities to take place. In the ST, it is also important to start defining ICT requirements, which the FSPs should start considering for the next stages of the LFM. The standard steps towards secure communication mechanisms should also be considered, as this ensures security and can be achieved by following the required protocols, which do not typically pose participation challenges for the FSPs.

On the MT, the target model is to have the activation process fully aligned with the service needs, as at this point, it is assumed that the FSPs are technically ready to adopt the required mode of activation. The same applies regarding reaching the fully planned functionality of the ICT platform and the deployment of needed assets to support streamlines, secure, and reliable activations. Such mechanisms can also be integrated in the operational processes of the SO and the FSPs. In the MT, combinations of scheduled and direct activation can also be considered to provide the SO with additional levers to address the grid flexibility needs. This combination is currently considered within MARI (Manually Activated Reserves Initiative), the European implementation project for operation of the European mFRR platform and can be potentially extended to LFMs. However, the costs and benefits of such combination of scheduled and direct activations applied to the LFM setting, and the impacts thereof on the different parties directly or indirectly involved, is an area that requires further analyses.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-5).

*Table 4-5: Elements covered in the NC DR [10] on activation - Compliance check*

| Regulatory check – Activation | |
|---|---|
| Mode of activation as part of product definition. | ✔ |

The NC DR does not prescribe a specific choice between manual or automatic activation. Instead, the mode of activation is included in the list of product attributes in article 38. Article 32 further states that the rules for the market-based procurement of local services, defined by all SOs within a MS, shall specify the processes and responsibilities for the selection and activation of bids.

### *4.2.4 Settlement*

Settlement is a key step of any LFM, as it covers (i) the ability for SOs to fairly remunerate FSPs while keeping costs at a minimum for consumers, and (ii) for FSPs to be remunerated accurately, thus meeting the double-ended goal of discouraging their intentional deviations from LFM-agreed nominations and further incentivising their continuous participation in the LFM. Settlement is fundamentally based on first setting up a baseline defining framework, followed by a verification step for flexibility activation (to quantify the amount of delivered flexibility with respect to the computed baseline), and a penalty defining step in which penalties for deviations from the committed flexibility volumes by the FSPs are computed and applied. In addition, flexibility activation by independent aggregators impacts other parties, such as the suppliers of the consumers involved and BRPs thereof, leading to different possible independent aggregation models involving perimeter corrections to neutralise the impact on the BRP positions and financial compensation mechanisms to compensate suppliers for the foregone revenues. Any transactions involved in such schemes fall also within the scope of the settlement process. Figure 4-6 includes the key success features for baselining, verification, independent aggregation, and penalties.

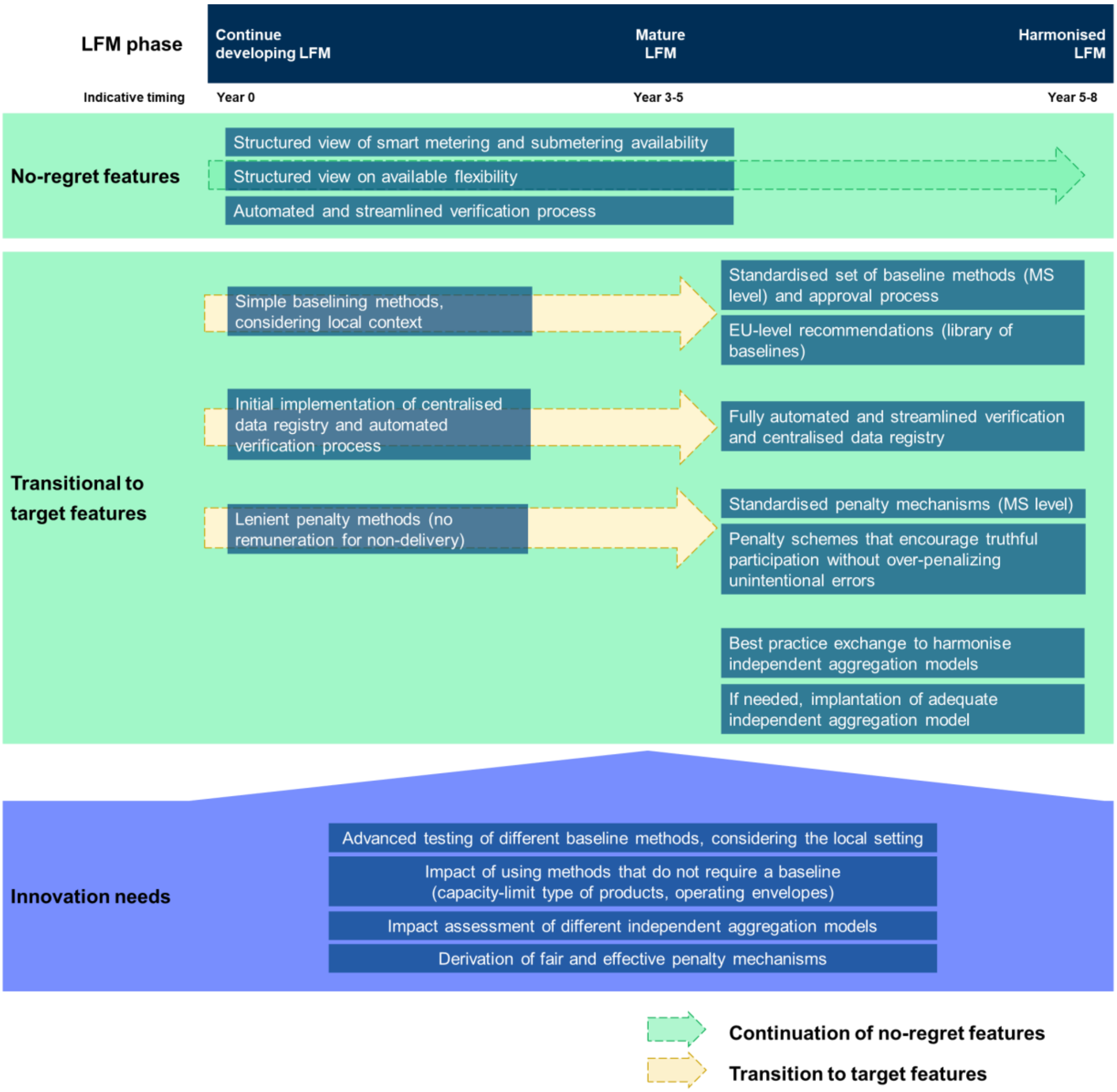


*Figure 4-6: Key success features for baselining, verification, independent aggregation, and penalties (Source: VITO own figure).*

The first two no-regret features for the settlement process, are linked to eventually being able to properly define baselines and/or to identify whether major baseline difficulties can structurally impede the viability of the LFM approach[20]. To do so, it is recommended that one obtains a structured view of all the dimensions linked to settlement, that is: nature of the service(s) procured, status of smart meter and sub—meter roll-out, and nature of locally available flexibility. In this regard, a **view on the current metering base** (and its evolution in the next years) is essential to identify the level of smart metering and submetering that currently is in place and projected to be deployed in the next years. That, along with a generated **view on available flexibility from the local FSPs** (e.g., features include whether FSPs have assets with known/pre-defined schedules, whether the included assets have sub-metering in place, or whether the delivered flexibility is based on aggregated multi-type DERs) would directly impact the list of baselining methods that

[20] e.g., shifting from volumetric flexibility delivery to capacity limits, wherein limits on offtake or injection at a certain moment for a particular connection are imposed rather than sourcing flexibility volumes from those connections.

could be implemented[21], and the verification and possible penalty steps that may follow. Thirdly, aiming for **automatic verification**, in which the metered data after activation is compared automatically to the computed ex-ante baselines, is a recommended no-regret feature. Automating this process helps streamlining it, reducing administrative efforts as well as human errors, and improving the operational speed and accuracy, especially in situations where the number of participants and submitted bids grow.

In terms of ST success features, as defining adequate baseline methods can induce high complexities in the initial phases of an LFM, a ST success feature is to first allow the initial setup of the LFM based on **simplified baselining methods** (e.g. self-reporting baseline coupled with adequate testing, or simple historical average-based schemes) with a default defined (set of) methods in place. This can then be coupled with a parallel testing of the viability of different more-advanced methods, to identify the applicability, benefits, and shortfalls of each (see further 'innovation needs'). Secondly, early adoption stages of a **centralised data platform for verification** can play a key role in the ST, through which all participants can gain experience with the automated verification process and the use of the data registry. A final ST success feature is the **testing of lenient penalty methods**. This testing can start from lenient applied penalties, such as a simple withheld remuneration for flexibility volumes non-delivered with no punitive fees below a certain delivery threshold. Such simplified penalties reduce risks to new entrants, thus minimising the barriers to entry while testing in parallel more advanced penalty methods. It is important, however, to have clear rules regarding penalties, that participants can easily understand and follow. Experimenting with more advanced schemes in the ST is also essential. In this regard, learning from other flexibility services, e.g., balancing services, can be used here to identify appropriate penalty methods for no or partial delivery of flexibility. This step serves to build up knowledge and can be based on a virtual parallel run during initial LFM phases.

On the MT, it is recommended that **applicable baseline methods are defined in a coordinated manner at MS level**, which can also rely on a **list of potential baselines defined at EU level**. The goal is to reduce the disparity of applied baselines, thus empowering FSPs activities over different flexibility markets. This can be coupled with a developed approval process in place at MS level for adding additional baselining methods as required. The more mature the market, the more advanced baselining and verification structures would need to be integrated to enable the participation of aggregated, potentially non-sub-metered flexibility. In this respect, alternatives can be considered, such as capacity-limiting products, in the event where flexibility volume-based services become extremely challenging to accurately baseline. A **fully automated and streamlined verification method** is a key success feature in the MT, reducing latency, and providing full transparency based on a centralised data hub (e.g., independent data registry as part of the flexibility register) in which transactions and flexibility activations are automatically logged and used for verification and settlement calculations, identifying any discrepancies, avoiding double-counting for activated flexibility, and keeping records which can be consulted for resolving disputes. The neutral handling of the data and the provided information regarding the verification process/calculation would ensure transparency for all actors involved. These functionalities can be potentially collectively covered by an extended scope of flexibility registers, which serves as a centralised data registry that enables not only PQ, but also baselining, and streamlined verification processes. **Standardised penalty methods** constitute a MT success feature, which are based on internalizing the experience build from different markets to define accurate and fair penalty structures for no or partial delivery. Such methods go beyond a mere non-remuneration for non-delivered flexibility but would also price in the costs borne by the SO for that non-delivered flexibility volume. The calibration of such penalties is essential

[21] Indeed, these elements directly impact the accuracy, integrity, and practical applicability of different baseline methodologies as detailed in [63].

to incentivise truthful behaviour without deterring participation, which constitute a key technical area for further analyses. Penalty structures would also sanction/disqualify FSPs for repeated violations. With respect to aggregation models, after the testing stage in the initial steps, **independent aggregation models** can be implemented on the MT based on the previous testing and accumulated experience. In this respect, **best practice exchange** to ease implementation, costs, and administrative burden and foster harmonisation of independent aggregation models is required.

As indicated above, a first important innovation need is linked to **advanced testing of different baseline methods**. Indeed, a number of academic papers have analysed different possible baseline methods and investigated their accuracy, simplicity, and integrity (i.e., sensitivity to manipulation) for different application settings. The testing of such methods will then project these academic findings to the local context, thus resulting in a set of agreed baseline methodologies that are both approved by the SOs as well as applicable for different types of FSPs. Such real-world testing requires dedicated future analyses, which can also make use of lessons learned from other sites and LFM initiatives. The testing of such baseline methods is coupled with an inherent testing of the verification process, thus investigating whether the volume of procured flexibility registered closely reflects the actual change to the net consumption as compared to the counterfactual baseline. Secondly, when new, **innovative products** are being implemented (such as capacity-limit type of products) or when specific methods such as operating envelopes are being used, it is important to further research the impact of using such method on the non-requirement of having a baseline. In addition, generating a structured view on the impacts of flexibility activations on the affected BRPs and suppliers is quite essential to (i) identify whether flexibility activation induce any structural disadvantages to any of those parties, and (ii) analyse the impacts of the implementation of any **independent aggregation model**, namely, the uncorrected model as compared to solely implementing perimeter correction without financial compensation, as compared to complementing perimeter correction with the central settlement scheme, or adopting a corrected model to neutralise the impacts on both the BRP and suppliers. Such an assessment must consider prolonged periods to endogenize rebound effects as well as the effects of different scenarios driving the impacts (loss or revenue) experienced by the different parties such as the flexibility activation direction (upward vs downward) as well as the sign and volume of the imbalance price, the service delivery (LFM) price, and the day-ahead market price (as the latter impacts retail pricing). It is not always apparent what kind of revenues or losses each party may incur, and if any of the parties will be put at a disadvantage. Such analysis will identify whether there is a need for implementing perimeter correction or financial compensation, and which aggregation model to adopt, especially focusing on the context of LFMs, which can involve activation volumes that are much lower than those of balancing services, thus reducing the impacts experienced by the different parties. Regarding independent aggregation models, the need for compensation mechanisms can therefore be relaxed on the ST, and experimentation must start to identify first whether there is a persistently experienced negative impact by any of the parties, and to test the appropriate independent aggregation model to follow. In terms of **penalty methods**, it is important that they are based on the obtained knowledge on the accuracy of the potential baseline methods (with their link to the structured views as discussed in the no-regret features). Penalty methods should aim to encourage truthful participation, i.e., FSPs would not have an incentive to willingly deviate from their committed flexibility volumes within the LFM. However, errors may still occur. It is then important to penalise such errors proportionally and not impose overly punitive measures, as heavy fines can discourage participation of FSPs, and may not even be collectable due to the financial implications they impose on the FSP. Further research and insights from pilots and other markets are necessary to further innovate on this topic.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-6).

*Table 4-6: Elements covered in the NC DR [10] on settlement - Compliance check*

| Regulatory check – Settlement | |
|---|---|
| Rules for settlement shall include procedure for calculating the activated volume and delivery of local services, using the respective baseline, when necessary. | ✔ |
| Baseline methods should contain a balance of the essential qualities of accuracy, simplicity, integrity and alignment. | ✔ |
| The national TCs will include the details necessary to create the baselines. | ✔ |
| European registry for all implemented baselining methods. | ✔ |

According to Article 35 of the NC DR, the rules for the settlement of market-based procured local services shall include a procedure for calculating the activated volume and the delivery of local services, using the respective baseline where necessary, and taking into account compensation effects, if applicable. The NC DR thus provides some flexibility to experiment with alternatives which do not require baselines. Furthermore, Article 14 emphasises that baselining methods, defined within the national TCs, must be recalculable, transparent, precise, accurate, and unbiased. It also calls for the establishment of a register of baselining methods based on all MS' approved approaches. These provisions align well with our key success features.

The more detailed elements on the aggregation model which were mentioned in the previous NC DR [129] have been removed from the current version of the NC DR as proposed by ACER. The provisions in the area of aggregation models will therefore be handled through updates in the EB regulation. The current proposal leaves room to have different aggregation models in different MS.

### *4.2.5 Gaming*

Figure 4-7 shows a summary of the three types of key success features related to gaming in the context of LFMs. These will be further described in more detail below the picture.

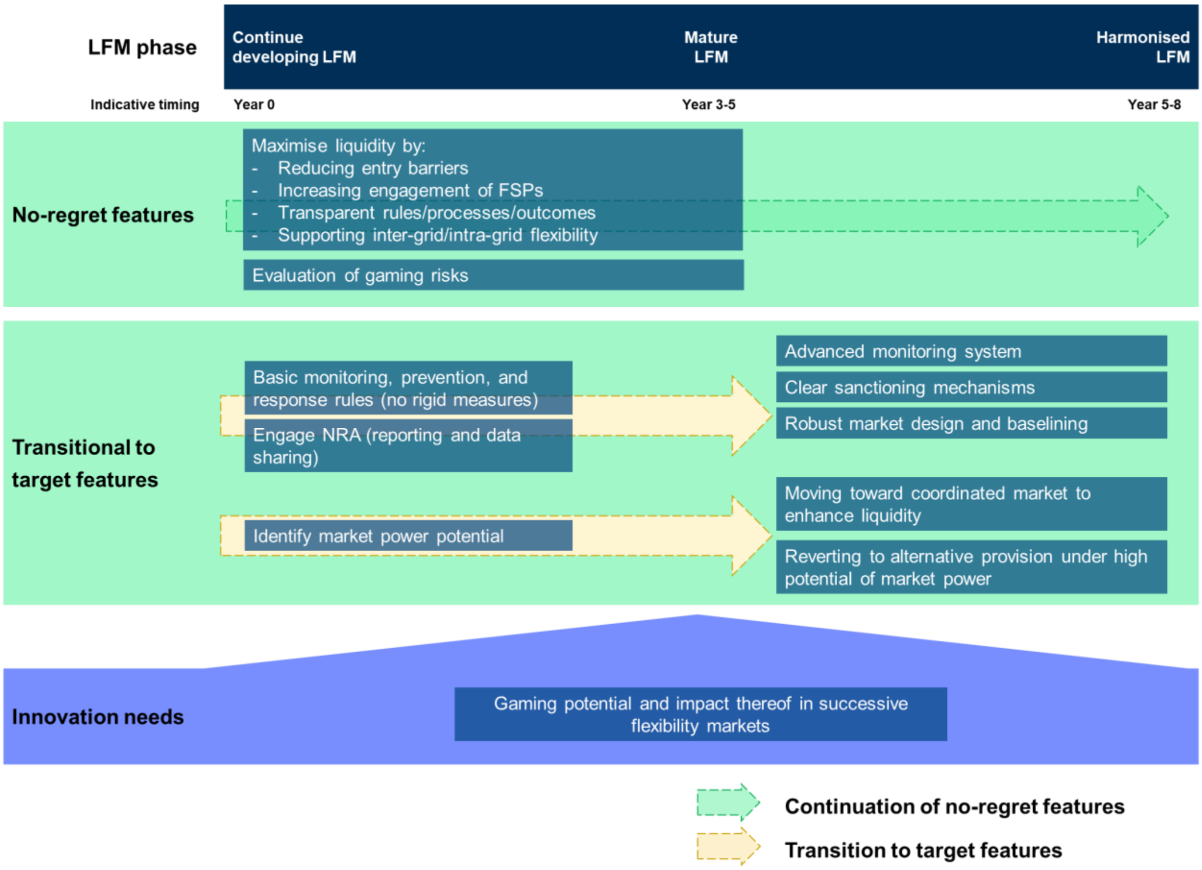


*Figure 4-7: Key success features gaming (Source: VITO own figure).*

A well-designed LFM should proactively address the risks of gaming through a set of no-regret design features that promote efficient operation. As liquidity aspects are main challenges for LFMs and a key driver for gaming risks, reducing entry barriers is essential to **increase market liquidity** and dilute the potential for individual actors to exert market power. Additionally, engaging potential FSPs early and consistently as well as ensuring clear, transparent participation rules and market outcome disclosures can improve participation as well as enhance trust and incentivise consistent, rule-abiding involvement. Enabling flexibility provision from different parts of the grid (intra-grid) and from other interconnected grids (inter-grid) increases the pool of potential participating FSPs. As such, reducing structural limitations (grid-based or contractual-based) to allow intra-grid and inter-grid delivery of flexibility is a no-regret feature. Broad participation by a diverse pool of FSPs lowers the risk of manipulation and creates a more competitive environment. As such, aiming for market designs that allow pooling effects and prevent subsequent market manipulation (i.e., taking actions in one market to create a need in the following market layer) is essential to ensure market integrity. Indeed, considering such market manipulation risks in the market design phase is a no-regret feature. Finally, the **systematic evaluation and monitoring of gaming risks** should be an integral part of the market design process, allowing MOs to anticipate vulnerabilities and start developing mitigation measures. Notably, gaming risks are more likely to emerge in early-stage LFMs, where market immaturity and low liquidity can give rise to power concentration concerns. These imbalances can be progressively resolved through continued market development and awareness-building, helping to mature the market and foster a more robust and competitive environment over time. In cases where market power is observed or suspected, the ability to revert to alternative flexibility provision mechanisms serves as a safeguard to mitigate gaming impacts.

It is important in the ST not to have rigid participation rules to enable the setup and initial functioning of the market. Hence, **basic monitoring, prevention, and response rules** may be implemented to address potential gaming effects in early stages rather than fully developed sanctioning rules. However, it is important to **identify potential sources of market power** early on and implement preventive strategies to limit their influence. In this respect, the application of cost caps (similar to auction price limits) in situations of low liquidity, where these cost caps mirror the cost of other alternative flexibility measures that the SO can implement, can be effective measures to be implemented in the initial stages of the market and then phased out later on to allow less interference in the market process. Finally, to strengthen governance and enforcement, it is recommended to **engage the NRA**, e.g., by reporting irregular behaviour, as a central and independent body responsible for oversight and enforcement. Furthermore, data sharing between the MO and the NRA is considered as an effective way to build trust and transparency in the market. Specially in early stages, learning from the experience of other markets and LFMs is indispensable to introduce measures to prevent gaming risks. In this respect, lessons should be drawn from existing markets, such as wholesale markets, as many risks faced by LFMs are not unique. While frameworks like REMIT (Regulation on Wholesale Energy Market Integrity and Transparency) may eventually be extended to LFMs, early-stage development may not require entirely new regulation. Instead, proportional and consistent treatment, informed by experiences from other European LFM initiatives, can be appropriate to avoid unnecessary complexity and support market growth.

In the MT, mitigating gaming risks in LFMs requires more sophisticated and systemic approaches. **Transitioning towards coordinated flexibility markets**, where pooling effects enhance liquidity, helps dilute the influence of individual market participants and reduces the likelihood of market power concentration. To further safeguard market integrity, it is essential to **implement robust market designs and baseline methodologies** with high integrity levels, which are more robust to manipulation. To support this goal, limiting information shared with FSPs that allow them to manipulate their baselining positions can be implemented (e.g., direction, timing, and location of flexibility activation well ahead of time), in addition to granting the right to audit to the SO to ensure that no gaming behaviour has taken place. Investigating the integrity of different baselining methodologies and the impacts of information available to FSPs on their potential behaviour is an area that requires further analyses. These features serve as structural defences against manipulation. Such key design elements also include rules preventing FSPs from offering the same capacity across multiple markets simultaneously, while including automatic bid expiration after acceptance and the inclusion of activated flexibility in the computed baselines. Additionally, **advanced monitoring systems** should be established to detect and address gaming behaviours, including untruthful bidding and manipulation of market baseline. To complement the monitoring system, **clear sanction mechanisms** should be in place for FSPs that engage in manipulative behaviour, providing a strong deterrent against gaming and reinforcing compliance. These should be accompanied by clearly defined response rules, providing a transparent framework for how gaming attempts will be addressed. These MT measures ensure a trustworthy market environment that can scale effectively with increasing levels of participation and complexity. In cases where the potential for market power is elevated, it might however be needed to consider and revert to alternative sources of flexibility provision to ensure reliable grid operation.

In terms of innovation needs, it is indicated that in the MT moving towards coordinated markets is recommended to enhance liquidity. In this context, further analysis on the gaming potential in successive flexibility markets and its impact is also further needed.
In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-7).

*Table 4-7: Elements covered in the NC DR [10] on gaming - Compliance check*

| Regulatory check – Gaming | |
|---|---|
| Adequate economic signals and avoidance of distorting incentives. | ✔ |
| Baselining methods shall prevent abusive behaviour. | ✔ |

According to article 32 of ACER's proposal for a NC DR, the rules for market-based procurement of local services must ensure efficient access, provide appropriate economic signals, and avoid distorting incentives for both service providers and SOs, while minimising capacity withholding and market abuse. Additionally, Article 14 states that baselining methods must be designed to prevent abusive behaviour. These provisions align well with the identified key success features.

## 4.3 Governance

### 4.3.1 Coordination

In this section, we describe the key success features related to coordination from two perspectives: (i) market coordination, and (ii) coordination with other solutions available to SOs.

#### 4.3.1.1 Market coordination

Figure 4-8 presents a summary of the three categories of key success features for market coordination. Each category will be described in more detail below the figure.

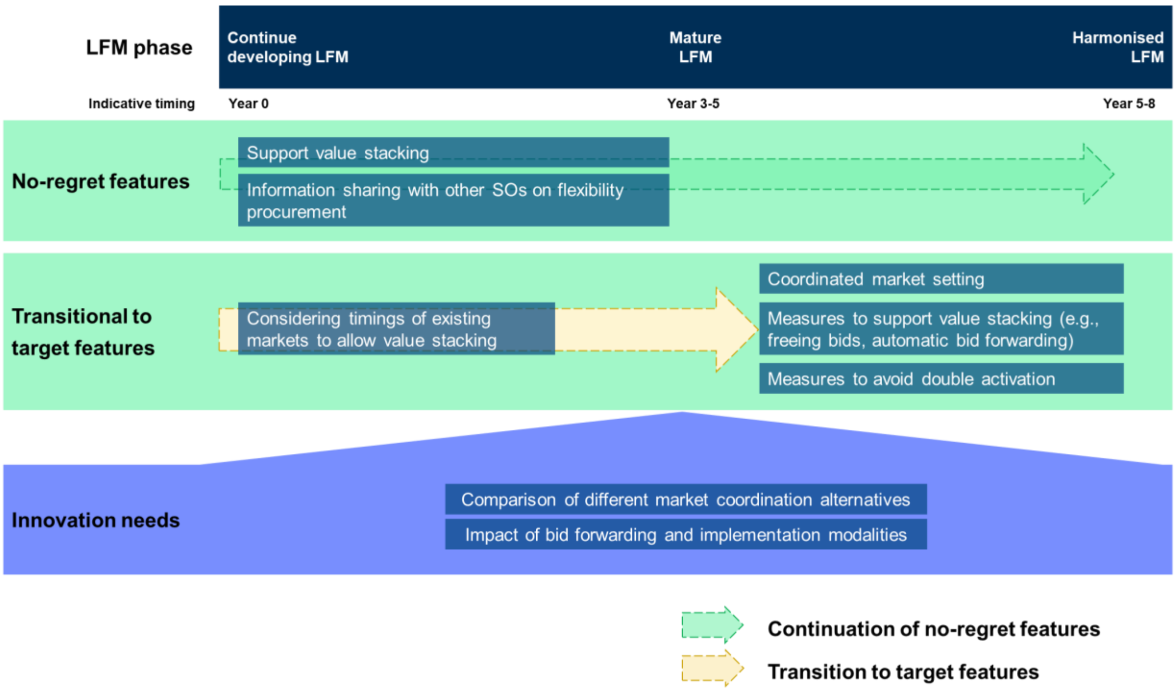


*Figure 4-8: Key success features market coordination (Source: VITO own figure).*

A key no-regret design feature in market coordination is to **support value stacking**. Allowing flexibility assets to provide multiple services across different markets, such as local grid support and balancing, and coordinating procurement decisions among SOs, not only improves the business case for FSPs but also enhances overall system efficiency. Additionally, effective **information sharing with connecting and impacted SOs** is essential. Transparent communication on flexibility procurement plans and outcomes ensures that decisions made in one part of the system are visible to others, reducing the risk of conflicting actions and enabling better-aligned, system-wide coordination.

In the ST, a critical design feature for effective market coordination is ensuring that the timing of LFM operations aligns with existing wholesale and flexibility market schedules. By **coordinating market timings**, FSPs are better positioned to stack value across multiple markets. This alignment facilitates greater market liquidity, improves the utilisation of flexible resources, and supports the overall efficiency and attractiveness of LFMs in their early stages.

In the MT, market coordination between DSOs and TSOs should be established through a **coordinated market scheme**, which can either be a sequential or common market structure, ensuring that each SO can access and procure flexibility from assets located across underlying grid levels. Such coordinated approaches enhance system efficiency and prevent conflicting actions. To further **enable value stacking**, **additional mechanisms** can be added. For example, freeing bids for participation in other markets and enabling optional automatic bid forwarding. In the latter case, FSP consent should be obtained, and their eligibility to participate in the receiving market should be ensured. Moreover, robust safeguard **measures to prevent double activation** of the same resource across multiple services should be put in place, ensuring reliability, transparency, and trust in the flexibility procurement framework.

In terms of innovation needs, two important elements that require further analyses are the **comparison of different market coordination alternatives** and the **impact and implementation modalities of bid forwarding**, including roles and responsibilities, as well as rules for combining and pricing these bids.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-8).

*Table 4-8: Elements covered in the NC DR [10] on coordinated markets - Compliance check*

| **Regulatory check – Coordinated markets** | |
|---|---|
| Interrelation with the DA, ID and balancing markets should be considered. | ✔ |
| Each SO has to coordinate with connecting and impacted SOs and exchange all necessary information. | ✔ |
| LFMs should facilitate value stacking. | ✔ |
| The procuring SO, on behalf of the FSP, may forward bids for local services | ✔ |

Article 32 of the current NC DR specifies that the rules for market-based procurement of local services shall include provisions on SO coordination and consider the interrelation with the day-ahead, intraday, and balancing markets. Article 48 further highlights the importance of cooperation between SOs, while article 45 emphasizes that the national TC for SO coordination must ensure that balancing, physical congestion, and voltage issues are addressed in a consistent and efficient manner. Bid forwarding is addressed in article 33, which states that, subject to the service provider's consent, the procuring SO may forward bids for local services to other markets on behalf of the provider, as defined in the procurement rules. Article 52 outlines the data exchange requirements between SOs needed to enable such coordination. All these provisions align well with our identified key success features.

#### 4.3.1.2 Synergy with other flexibility mechanisms

Flexibility can be obtained through other types of flexibility mechanisms, such as tariff-based approaches (implicit mechanisms) and FCAs. Figure 4-9 summarizes the three types of key success features on how to consider other flexibility mechanisms.

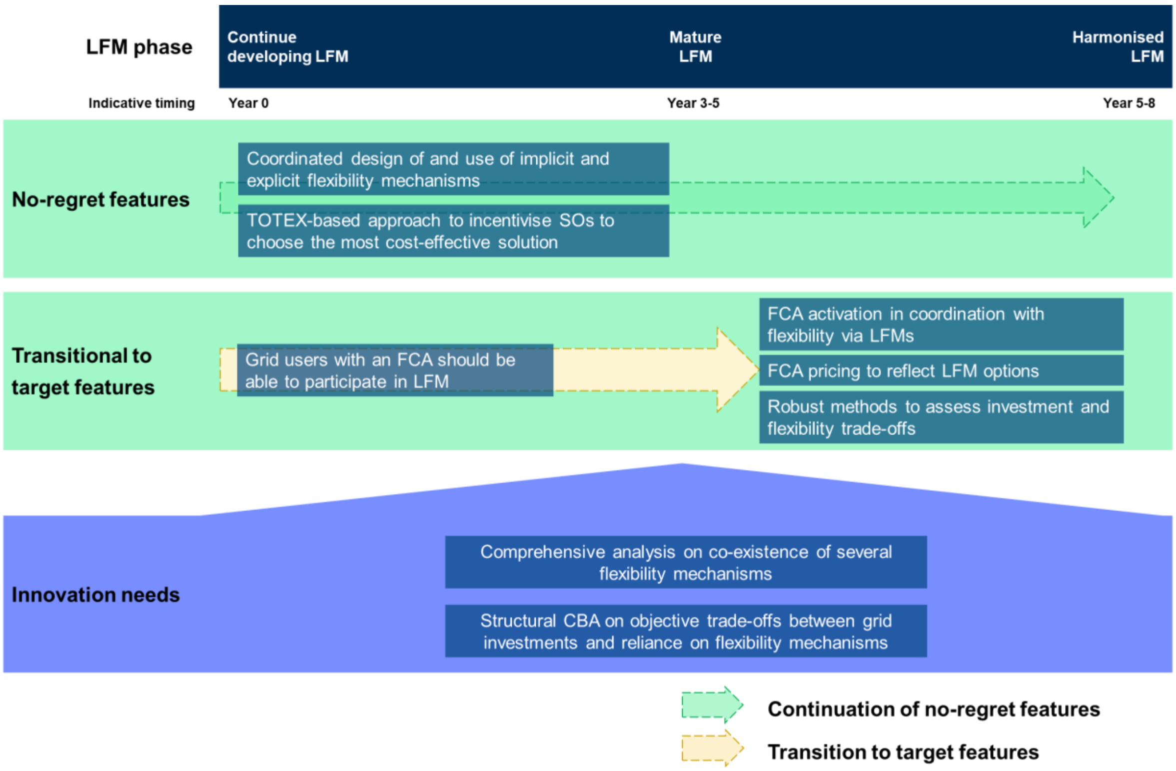


*Figure 4-9: Key success features synergy with other flexibility mechanisms (Source: VITO own figure).*

Therefore, beside ensuring effective coordination between different flexibility markets, good synergy between LFMs and other mechanisms is crucial as well. A fundamental no-regret approach to strengthening this synergy is to ensure a **coordinated design of both implicit (e.g., tariff signals) and explicit market-based flexibility mechanisms**. This coordination is essential to prevent unintended disincentives for participation, such as situations where engaging in LFMs would negatively impact grid tariff payments for system users. Designing tariff schemes in alignment with LFMs can not only help promote fairness and facilitate broader participation but also improve the overall system efficiency. Moreover, adopting a **TOTEX-based regulatory model for SOs** incentivises them to consider both operational expenditures (e.g., purchasing flexibility) and capital expenditures (e.g., grid reinforcements) in a balanced way. This allows SOs to select the most cost-effective and efficient solutions, supporting system optimisation and making full use of available flexibility resources.

In the ST, ensuring **access to LFMs for grid users under FCAs** is a crucial step to unlock the potential of existing flexible connections and promote active market participation.

In the MT, as **FCAs** evolve to fit within a suite of consumer contracts, that can support the flexible behaviour of users and safeguard the grid, such mechanisms can also be **linked and interact with LFMs**. For example, capacity limitation type of products (or OE-based products) can be a way in which the **pricing of FCAs** can be set **based on a market mechanism**. Additionally, while LFMs and non-market-set FCAs co-exit, FCAs' activation should compete directly with ST energy bids in LFMs to ensure transparent and economic decisions. Such coordination between LFMs, grid tariffs, and FCA schemes are MT success features of LFMs. Finally, a **robust methodology** must be used **to make an objective trade-off between grid investments and reliance on flexibility mechanisms**, consistent with EU regulatory guidelines, thus ensuring LT system efficiency and regulatory alignment.

In terms of innovation needs, a **comprehensive study on the co-existence** of these different flexibility mechanisms and **a structural CBA for trade-off analysis** are needed to support the synergy. The later, in particular, is required to support the MT target feature of assessing investment and flexibility trade-offs.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-9).

*Table 4-9: Elements covered in the NC DR [10] on synergy with other flexibility mechanisms - Compliance check*

| Regulatory check – Synergy with other flexibility mechanisms | |
|---|---|
| SOs should use the most efficient and effective solution or combination of solutions. | ✔ |
| FCAs should not replace or restrict market-based procurement of local services. | ✔ |
| FCAs should be coordinated efficiently with products for local services. | ✔ |
| System users with FCAs should be able to access electricity and system services markets. | ✔ |

In general, according to Article 48 of the current NC DR, SOs shall select the most cost-effective solution, or combination of solutions, that can be applied in a timely and effective manner to ensure secure system operation when addressing physical congestion and voltage issues. This aligns well with our no regret features of a coordinated design of implicit and explicit flexibility mechanisms and establishing appropriate incentivisation mechanisms for SOs to choose the most cost-effective solutions.

Although implicit mechanisms, such as dynamic distribution tariffs, fall outside the scope of the NC DR, we consider alignment between implicit and explicit flexibility a critical aspect. The current NC DR does emphasize that FCAs should not replace or restrict market-based procurement of local services. Specifically, Article 31 states that activation of FCAs must not distort the market. When local service markets and FCAs coexist, FCA activation must be coordinated with relevant local service products to ensure effectiveness, overall system cost-efficiency, and users with FCAs shall be able to provide balancing and local services and participate in all relevant wholesale markets.

### *4.3.2 Information sharing*

Figure 4-10 provides key success features related to information sharing, which will be further explained in this section.

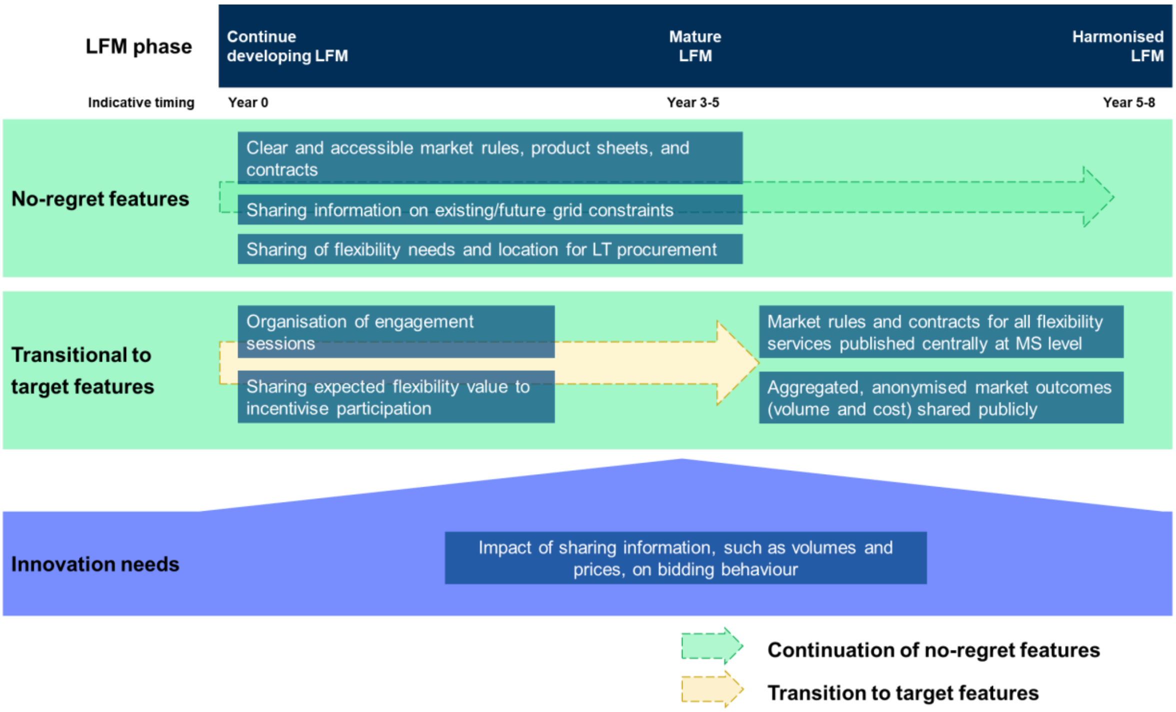


*Figure 4-10: Key success features information sharing (Source: VITO own figure).*

Effective information sharing is a foundational no-regret design feature for the successful development and operation of LFMs. To foster transparency and build trust among market participants, it is essential that **market rules, product descriptions, and applicable contracts are made publicly available and easily accessible** well in advance of actual procurement activities. This enables potential participants to fully understand the market framework and prepare accordingly. Additionally, the public **sharing of information on existing and anticipated grid constraints** and in which zones of the grid these occur, for example, through congestion maps, allows FSPs to identify whether and where their services may be needed. Similarly, for LT procurement planning, openly **publishing information on flexibility needs and their geographical locations** further supports informed participation, encourages proactive investment in flexible resources, and enhances the overall efficiency and responsiveness of the flexibility market.

In the ST, targeted information-sharing measures can play a crucial role in stimulating engagement and participation in early stage LFMs. **Organising informational sessions** such as webinars is an effective way to raise awareness among FSPs and grid users, helping them understand market processes, rules, opportunities, and participation requirements. Furthermore, in early phases when market signals are not yet well established, **providing indicative information on the expected value of flexibility**, such as the maximum price the SO is willing to pay and the expected number of activations, can incentivise participation and help stakeholders make informed decisions not only about offering flexibility but also investing in flexibility assets.

In the MT, robust and centralised information sharing mechanisms are essential to ensure transparency, coordination, and trust in LFMs. All **market rules and applicable contracts for flexibility services**, including both local and balancing services, should be made **available through a public and centralised platform at the MS level**. This supports harmonisation, simplifies access for FSPs, and reduces administrative burdens. Additionally, **market outcomes, such as procured volumes and associated costs, should be shared publicly in an aggregated and anonymised format** shortly after each market session, for both LT and ST procurement. This transparency fosters stakeholder confidence, supports market analysis, and enables continuous improvement of market performance. It is worth noting that **sharing information**, such as volumes and prices, might **influence the bidding behaviour** of market participants. Therefore, in terms of innovation needs, **further impact analysis** is needed to maintain the competitiveness and efficiency of the market.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-10).

*Table 4-10: Elements covered in the NC DR [10] on information sharing - Compliance check*

| Regulatory check – Information sharing | |
|---|---|
| Each procuring SO shall publish clear information on the market sessions. | ✔ |
| SO should publish on the expected need of local services. | ✔ |
| SO shall publish the product needs for the LT procurement of local services. | ✔ |
| Publishing of aggregated information on offered and selected bids for local services. | ✔ |
| Common information platform on market-based procurement for local services at MS level. | ± |
| Possibility to not publish certain information in case of market abuse concerns. | ✔ |

The current version of the NC DR aligns well with the proposed key success features regarding information sharing prior to market opening, prior procurement, and after procurement. According to Article 26, SOs must publish a non-confidential version of the flexibility information system, including at least data on service providers and the total capacity prequalified or verified per technology and product. Additionally, article 33 requires that a common information platform for market-based procurement of local services is maintained within each MS. We, however, recommend extending this requirement to cover all system services, including balancing. Article 37 further specifies that transparent details on market sessions, such as the number and structure of sessions, gate closure times, and product information, must be published. Based on the expected physical congestion or voltage issues, SOs should also publish, at least as frequently as the NDP, indicative information for the expected need for local services. In addition, they need to publish information necessary for the operation of local markets. For the LT procurement, this includes product needs, including the direction, with sufficient time and locational granularity. Following the same article, procuring SOs are also required to publish aggregated and anonymized market outcomes, including offered and selected bids.

However, specific data such as prices and volumes may be withheld if publication poses a risk of market abuse or undermines the effective functioning of electricity markets. This supports our point that further analysis is needed on how sharing information - such as volumes and prices - affects market participants' bidding behaviour.

### *4.3.3 Roles and responsibilities*

Figure 4-11 shows the key success features related to roles and responsibilities.

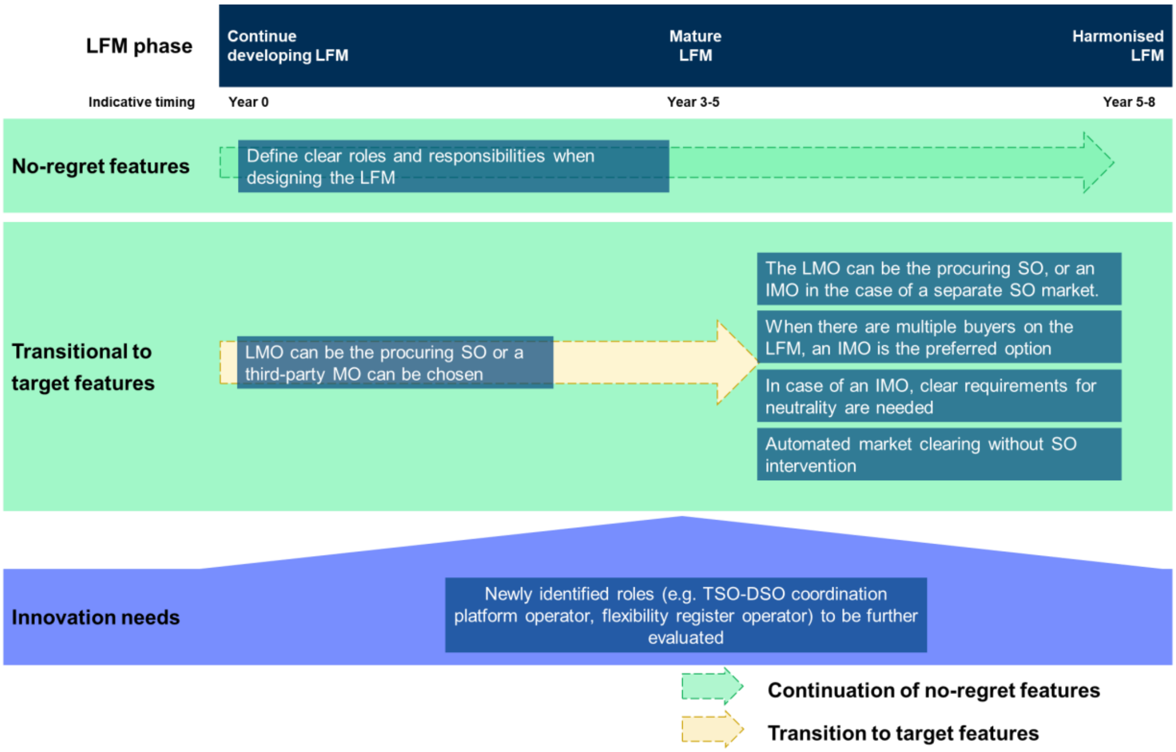


*Figure 4-11: Key success features roles and responsibilities (Source: VITO own figure).*

In designing LFMs, **clearly defining roles and responsibilities** is essential to ensure transparency, efficiency, and trust among stakeholders. This is considered a no-regret feature. On the ST, the **LMO role can be fulfilled either by the procuring SO or delegated to an independent third-party MO**.

In the MT, when the market remains a **separate SO market**, the ST feature can also remain. However, in case LFMs evolve to accommodate multiple buyers, e.g., DSOs, TSOs, or even commercial entities, **a third-party LMO becomes the preferred option** to maintain neutrality and operational independence. In such cases, **clear and enforceable neutrality requirements must be established** to avoid conflicts of interest and ensure equal access for all buyers. On the MT, regardless of who takes up the role of the MO, there should be no intervention in the final selection of bids. Neutrality can best be demonstrated through **automated clearing**, according to clearly defined market rules (see also section 4.2.2). In addition, LMO should demonstrate technical competence, and robust market monitoring mechanisms should be applied. Structured, auditable processes and historical records ensure that decisions can be verified as impartial and consistent with market rules.

In terms of innovation needs, further analysis is needed to **evaluate newly identified roles**, such as a TSO-DSO coordination platform operator and a flexibility register operator, both of which will play a key part in supporting seamless coordination and information exchange across different parts of the flexibility market ecosystem.

In the remainder of this section, an assessment is made of the compliance of our key success features with ACER's proposal for a NC DR (see Table 4-11).

*Table 4-11: Elements covered in the NC DR [10] on information sharing - Compliance check*

| Regulatory check – Information sharing | |
|---|---|
| A third party or the procuring SO may operate the LFM | ✔ |
| Requirements regarding transparency, neutrality and business separation | ✔ |

Similarly to our study, no specific actor is appointed to the role of LMO in the NC DR. According to the current NC DR, a third party - other than the DSO or TSO using the service - may operate the market, either through delegation by the procuring SO or by assignment at the national level by the NRA (Article 8). Article 32 specifies that the rules for market-based procurement of local services must include additional requirements regarding transparency, neutrality, and business separation in the event of a conflict of interest for tasks assigned to a third party. Additionally, Article 33 states that any party performing tasks related to the market-based procurement of local services must be unbundled from market activities such as production, supply, and service provision.

# 5 Recommendations and conclusions

## *5.1 Specific policy recommendations*

From the identified key success features, specific policy recommendations can be derived. In the table below, we summarise the key success features from the previous chapter that are already closely linked to policy at the MS and EU level and identify some additional policy measures which can be taken to support the realisation of the key success features, such as for instance monitoring of certain LFM design aspects at EU level. For each recommendation, we indicate whether it is a ST no-regret or LT target measure similar as for the key success features in chapter 4[22], and add its level of compliance with the ACER proposal for a NC DR (✔ complete compliance, ± medium compliance, ✘ no compliance, not covered in the ACER proposal for a NC DR) based on the regulatory check in chapter 4 for each topic. For a more detailed explanation on the compliance check we refer to the different sections in chapter 4. These recommendations aim to guide the implementation of LFMs across Europe.

*Table 5-1: Specific policy recommendations on design and implementation of LFM*

| | Recommendation | Type | Compliance |
|---|---|---|---|
| **Products** | Products defined based on a common (EU) list of attributes; Attributes should be optional allowing to define more simple products for local services. | ST no regret | ± |
| | Requirements set at EU level to have technology neutral and non-discriminatory products and to allow (spatial) aggregation and portfolio-based bidding when underlying grid needs and physical constraints allow it. | ST no regret | ✔ |
| | Alignment between SO at MS level to come to a limited set of stable standardised local products at MS level. | MT target | ✔ |
| | Coordinated product definition with existing markets; Harmonising products to the extent possible, so that they can be used for different services. | MT target | ± |
| | Standardised approach to include locational information in product definitions. | MT target | ± |
| | Monitoring of products for local services at EU level to incentivise knowledge sharing. | MT target | ✔ |

[22] It should be noted that policy recommendations are deemed unnecessary for the short-term transitional features, as these constitute temporary measures intended to initiate market operation, whereas regulation should guide the evolution toward the target LFM design.

| | | | |
|---|---|---|---|
| **SP PQ and product qualification** | Common flexibility register at MS level. | MT target | ✓ |
| | Common PQ steps / approaches for all flexibility services at MS level to avoid duplication whenever possible. | MT target | ✓ |
| | Simplification measures at MS level while ensuring that all FSPs and flexible assets are prequalified on the same basis. | MT target | ✓ |
| **Grid PQ** | TSO-DSO advanced data sharing and coordination in the assessment of their respective grid states at MS level. | MT target | ✓ |
| | More granular or dynamic grid checks based on closer to real-time forecasts. | MT target | ✓ |
| **Procurement** | Overall market objective of LFM should be to minimise total flexibility procurement costs. | ST no regret | ✓ |
| | All prices should be market-based (both for capacity and energy procurement). | ST no regret | ± |
| | Reserved flexibility competes with ST bids or is released if not needed. | MT target | ✓ |
| | Market design and procurement rules to be decided on MS level. | MT target | ✓ |
| | Automated market clearing without SO intervention for ST procurement. | MT target | Not covered |
| **Activation** | Automatic and/or manual activation depending on the requirements of the service. | MT target | ✓ |
| | Standardised communication for activation (platform-based communicated). | MT target | Not covered |
| **Settlement** | Automatic verification process comparing metered activation with the baseline. | ST no regret | ± |
| | Fully automated and streamlined verification and data registry handled by a neutral party. | MT target | ± |
| | Standardised and reduced set of baselining methods at MS level informed by EU-level recommendations (library of baselines) adhering to the main principles of simplicity, accuracy and integrity. | MT target | ✓ |
| | Approval process in place at MS level to add additional baselining methods. | MT target features | Not covered |

| | | | |
|---|---|---|---|
| | Structured approach to identify the need for independent aggregation models and the choice thereof. | MT Target features | Not covered |
| | Best practice exchange to ease implementation and foster harmonisation of independent aggregation models. | MT Target features | Not covered |
| | Standardised penalty mechanisms at MS level, that encourage truthful participation without over-penalizing unintentional errors | MT Target features | Not covered |
| **Gaming** | Advanced monitoring systems to detect gaming behaviours, including untruthful bidding and manipulation of market baseline. | MT Target features | Not covered |
| **Coordination** | DSOs and TSOs procure flexibility through coordinated markets, where each SO has access to flexibility in the underlying grids, and value-stacking potential of FSPs is maximized. | MT target | ✓ |
| | Coordinated design of and use of implicit and explicit flexibility mechanisms. | ST No regret | ± |
| | Development of a robust methodology to evaluate trade-offs of investments and flexibility mechanisms. | MT target | ± |
| **Information sharing** | Market rules, product sheets and applicable contracts for all flexibility services (including local as well as balancing services) available via a public and centralized location at MS level. | MT target | ✓ |
| | Publicly sharing of information on existing and future grid constraints, flexibility needs and location for LT procurement, and aggregated market outcomes. | MT target | ✓ |
| **Roles and responsibilities** | LMO can be the procuring SO or a third-party MO can be chosen in case of a separate SO market. | MT target | ± |
| | When there are multiple buyers on the LFM (e.g. DSO, TSO, commercial party), a third party LMO is the preferred option. | MT target | ± |

As already explained, to urgently launch LFMs across Member States, we propose initiating simplified market designs to gain early experience and build confidence among key stakeholders (SOs, FSPs, owners of flexible resources, NRAs, etc.), while simultaneously testing more advanced features that will enable the transition toward mature and ultimately harmonised markets in the MT. The recommendations presented above in Table 5-1 support this phased process, structured around the principle of "start simple, keep it gradual". Insights from the surveyed initiatives have demonstrated that excessive complexity at the outset often delays implementation and limits participation, whereas a gradual and pragmatic rollout enables faster learning and market uptake.

Member States are encouraged to establish their LFMs by implementing the "no-regret" measures from the outset, while progressively integrating target features over time. In the ST, it is recommended to define products based on common attributes, ensure technology-neutral and market-based procurement, and introduce basic verification processes. These measures can be implemented rapidly, removing most of the initial barriers and accelerating the establishment of functioning LFMs. In parallel, MT priorities should build on these foundations through increased product harmonisation, more advanced prequalification procedures, enhanced TSO–DSO coordination, and automated procurement and settlement, progressively adding complexity and increasing efficiency. This study further calls for standardised baselining, transparent information sharing and robust monitoring to prevent gaming. Overall, a timely and decisive rollout is critical to establish well-functioning LFMs that enable efficient, transparent, and scalable flexibility procurement, paving the way toward the target harmonised EU LFM model. The proposed approach is therefore not a compromise but a catalyst, enabling swift market activation and creating the right conditions – supported by needed innovation - to evolve toward the target LFM design.

## *5.2 Final recommendations*

In addition to the more specific policy recommendations discussed above, several overarching recommendations can be provided:

- The main take away of the study is that a lot of SOs together with their partners are still experimenting with LFMs. Given that SOs, FSPs, and other stakeholders currently lack extensive experience with LFM, it is recommended to **start with a simplified approach and gradually introduce greater complexity** as explained above. This will allow to swiftly kick start LFMs while supporting the transition toward a target LFM design as expertise, capabilities, market depth, and liquidity continue to develop.

- Overall, **more harmonised approaches to LFM product and market design should be pursued in the long term**, building on additional learnings in the coming years, while still allowing sufficient flexibility to accommodate local specificities where necessary. To support this harmonisation process, **experience sharing and monitoring at the EU level** are essential, along with the development of common frameworks and methodologies to limit unnecessary diversity. This need is seen across all key design aspects of LFMs, particularly in market models, product definitions, and baselining approaches. Such a process corresponds well with the two-yearly reporting by ENTSO-E and the EU DSO Entity based on data from market participants and national systems, as proposed in the draft NC DR, which also includes these topics [10].

- This study encourages MSs to swiftly establish simplified market designs to gain experience and build confidence, while simultaneously testing more advanced features to progressively integrate target features over time, as outlined in the first general recommendation. To support this gradual process this study identified some areas within LFMs where **further innovation and analysis are needed**, to evolve in the MT to a more mature and finally harmonised LFM. These include **product design** - such as incorporating activation parameters in reservation products and evaluating the benefits and costs of localized versus standardized product designs across services. Additional focus areas include developing solutions for more automated and standardized **qualification processes**, assessing the impact of product verification versus PQ, and evaluating the effectiveness of various grid PQ methods. It is also essential to determine the appropriate level of grid detail required at the PQ stage compared to the procurement stage. Further research is warranted to compare **different market coordination approaches** while improving **market-clearing** computational efficiency, particularly under complex formulations, and to advance the testing of different **baselining methods** and potential alternatives methods to using traditional baselining for local services. Moreover, there is a need for impact assessments of various independent **aggregation models** on the parties involved. Finally, the derivation of fair and effective **penalty mechanisms** should be pursued. For the various innovations mentioned, knowledge sharing between MSs recommended as explained in the previous point.

- **LFMs** are not stand-alone solutions and **should be fully integrated into the broader suite of flexibility mechanisms available to SOs**. An **integrated approach** is required for both **network planning and operation**. This includes the trade-off between grid investments and flexibility, considering implicit as well as explicit flexibility, for both DSOs and TSOs. To support this integration, the **remuneration structure for SOs** should be redesigned as current regulatory frameworks for DSOs and TSOs across Europe are often still CAPEX-biased, favouring grid expansion over flexibility solutions. Most countries still lack schemes that adequately reward SOs for procuring flexibility. Comprehensive incentives covering both capital and operational expenditures are needed to enable fair evaluation between flexibility and grid investments.[130], [131] In addition, to support integration, **robust methodologies should be developed to enable sound trade-off analyses** for selecting the most efficient combination of solutions. The majority of LFM initiatives indicated that they currently lack a robust method to perform trade-offs between different solutions (i.e. flexibility mechanisms and grid investments), and system operators across Europe are developing their own methodologies. However, it would be beneficial if MSs applied similar approaches when conducting these trade-offs to ensure methodological robustness and fairness of the methodology, so also here experience sharing at EU level would be essential.

- Although **gaming behaviour** has not been widely observed in the surveyed LFM initiatives, establishing **robust monitoring systems** already in the early stages of LFM remains essential to anticipate and manage potential risks as markets scale. These systems should be complemented by clearly defined and enforceable **mitigation measures**, including proportionate sanction mechanisms that can deter and address manipulative behaviour effectively. In parallel, **enhancing market liquidity** is a key structural lever to reduce the likelihood and impact of gaming.

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# Annex 1: Classification structure

*Table 0-1: Classification structure – Cat 1 - General information*

| Characteristic | Explanation |
|---|---|
| **Status of LFM** | The status of the LFM initiative. Here we distinguish between pilots and live markets. A pilot is typically limited in duration and is a trial run of the LFM before actual implementation. A live market entails actual procurement of flexibility by the SO via the LFM. In addition, we indicate whether the pilot or live market is in preparation, in operation, or finalised.<br>The considered options are thus:<br>- *Pilot (in preparation)*<br>- *Pilot (in operation)*<br>- *Pilot (finalised)*<br>- *Live market (in preparation)*<br>- *Live market (in operation)*<br>- *Live market (inactive)* |
| **Market maturity** | The maturity of the market is measured by the time elapsed since the initial opening of the market and thus indicates the number of years the LFM has been active. |
| **Buyer(s) of flexibility** | The party which procures the flexibility. LFMs can be single buyer or multi-buyer markets. We consider the following options:<br>- *DSO only;*<br>- *TSO only;*<br>- *DSO(s) and TSO(s);*<br>- *DSO(s), TSO(s), and commercial parties*<br>- *FSPs* |
| **Flexibility services** | Flexibility services procured via the LFM by SOs:<br>- *Congestion management*<br>- *Voltage control*<br>- *Balancing services*<br>- *A combination of the above-mentioned services*<br>Note: Both local services and centralised services can be mentioned here, but at least one of the services should be a local service to fit the definition of an LFM as presented above. |
| **Need location** | **Voltage level:** The nominal voltage of the portion of the grid in which the contingency occurs and the LFM is located. We grouped voltage levels according to the following classifications:<br>- *Low Voltage (LV) (Up to 1,000 volts (1 kV),*<br>- *Medium Voltage (MV) (Above 1 kV up to 36 kV),*<br>- *High Voltage (HV) (Above 36 kV up to 230 kV)*<br>- *Extra High Voltage (EHV) (Above 230 kV).* |
| | **Network topology:** Topology of the network where the need is located, which can be:<br>- *Meshed*<br>- *Radial*<br>- *Combination of both.* |
| | **Network portion:** portion of the network where the need is located, such as the *Distribution grid, Transmission grid, Interface between T&D grids*, etc. |
| **Type of assets** | The type of assets that can offer their flexibility to the LFM:<br>- *Residential*<br>- *Commercial*<br>- *Industrial*<br>- *Generation*<br>- *Storage*<br>- *All types of assets*<br>Note: Generation and storage can be residential, commercial and/or industrial assets, but can also be grid-connected assets, so these are separately mentioned. |
| **Type of market platform** | Whether the LFM initiatives deploys an in-house developed market platform or an existing platform from a commercial market platform provider. We thus consider the following options:<br>- *Own developed market platform*<br>- *Existing market platform* |

*Table 0-2: Classification structure – Cat 2 – Product design*

| Characteristic | Explanation |
|---|---|
| **Number of products** | Number of products which can be traded via the LFM. |
| **Product based on an existing product** | Product based on an existing product definition from balancing and/or ID/DA wholesale energy markets or not. |
| **Procurement of active/reactive power** | Product entails the procurement of active or reactive power. |
| **Capacity and/or energy product.** | In case of a *Capacity product* flexibility is reserved with the possibility to be activated during the reserved period.<br>An *Energy product* entails binding activation and delivery of flexibility. |
| **Remuneration** | Determines how the flexibility is remunerated, i.e. whether there is a *remuneration for availability* (reserved capacity) and/or *activation* (activated energy). |
| **Aggregation allowed** | Whether aggregation is allowed and in case it is, a description of the level of permitted spatial aggregation and/or portfolio-based bidding.<br>Spatial aggregation refers to the process of grouping flexible resources based on their geographical location within the network where the LFM is located.<br>In case of portfolio-based bidding, FSPs submit bids based on an aggregated portfolio of flexible resources rather than individual assets. |
| **Duration of delivery period** | Length of the duration of the delivery (minimum/maximum length requirement, a fixed duration). |
| **Maximum number of activations** | Maximum number of times an FSP can be requested to activate a product in a given time period. |
| **Full activation time** | Period between the activation request and the full activation of the product. |
| **Locational Information** | Grid location information included in the product definition.<br>The following options are considered:<br>- *Node-level*<br>- *Feeder-level*<br>- *Substation-level*<br>- *System-level*<br>- *Other* |
| **Symmetric / asymmetric product** | Determines whether only *symmetric* (upward volume = downward volume) products or also *asymmetric* products are permitted. |
| **Granularity** | The smallest possible increment in volume of the submitted bids. |
| **Minimum bid size** | Minimum permitted bid quantity for the product. |
| **Minimum resource size** | Minimum permitted resource size. |
| **Divisibility** | The possibility to clear only a part of the bid in quantity and/or duration. |
| **Bid format** | Information which needs to be included when placing a bid on the LFM, such as:<br>- Price<br>- Quantity<br>- Location<br>- Other |
| **Complex bid types** | The extent to which other information can be included in the bid to come to more advanced bid types. This can include different bid types, e.g.:<br>- Non divisible bids: can be cleared only at maximum quantity<br>- Partially divisible bids (fully divisible bids but with a minimum quantity clearing requirement)<br>- Exclusive bids: a set of bids from which at most one can be cleared<br>- Multi-part bids: a sequence of parent – child bids (or parent-children bids) in which a child can only be cleared if its parent bid is also cleared |

*Table 0-3: Classification structure – Cat 3 – Market design – Prequalification phase*

| Characteristic | Explanation |
|---|---|
| **Service provider prequalification** | Method applied for ensuring that the FSP fulfils the criteria for market access. This can include, amongst other, financial prerequisites, ICT system and communication requirements; etc. |
| **Product qualification** | Method applied for ensuring that the FSP fulfils the technical requirements to deliver the service, including whether the process is *ex-ante* (product PQ) or *ex-post* (product verification) and whether a PQ test is required. |
| **Grid prequalification** | Method applied for ensuring that the FSPs' service delivery does not endanger the reliability of the grid operation of connecting and impacted grids. |
| **Simplified prequalification** | Measures in the PQ process to encourage / simplify participation of small resources. |
| **Flexibility register** | A database that records and manages information about FSPs and the flexibility resources they represent available for procurement by SOs or other market participants. In the context of LFM, such register could be set up at the level of the individual LFM or could be shared with other markets. We therefore distinguish between the following options:<br>- *No flexibility register*<br>- *Flexibility register on the level of LFM*<br>- *Common flexibility register with other markets* |

*Table 0-4: Classification structure – Cat 3 – Market design – Procurement phase*

| Characteristic | Explanation |
|---|---|
| **Market timings** | The different timeframes and deadlines that govern the flexibility procurement within the LFM. It should be noted that these timings can apply to both the reservation of flexibility (procurement of capacity) and/or the procurement of energy. In the case of flexibility reservation, an energy procurement step is not always included. In particular, we distinguish between:<br>- *Gate opening time* (GOT): Timing when market participants can start submitting bids or offers for flexibility.<br>- *Gate closure time* (GCT): The deadline by which all bids must be submitted. Not all LFM have a fixed GCT.<br>- *Market Clearing time*: Timing when the bids are selected. Can occur at fixed timings or on a continuous basis within a predefined time window.<br>- *Publication time* (PT): Timing of the publication of market outcome. |
| **Market objective** | The objective to be met by the market clearing. Some potential market objectives are:<br>- *Maximising social-economic welfare*<br>- *Minimising total flexibility procurement costs*<br>- *Other* |
| **Clearing mechanism** | The type of clearing mechanism applied in the LFM refers to the process by which flexibility bids and offers are matched to determine the market outcome. We distinguish the following mechanisms:<br>- *Closed gate auction:* Fixed submission deadline ("closed gate") and bids are evaluated and matched in a single clearing process.<br>- *Continuous market:* Bids and offers are matched continuously as they are submitted. There is typically a time window in which bids are accepted.<br>- *Tender:* SOs invite FSPs to submit bids to supply local services over a defined period. This type of mechanisms mostly entails reservation of flexibility for a longer duration (LT contracts).<br>- *Bilateral trade:* Direct agreement between buyer (SO) and seller (FSP) to deliver flexibility with direct negotiation between them. |
| **Final bid selection** | Involvement of the SO for the final bid selection. This characteristic checks whether the final bid selection is completely automated or whether there is still an intervention or check from the procuring SO for the selection of the final bids. In the latter case, we refer to the bid selection as a manual bid selection. We distinguish the following options:<br>- Manual selection by SO<br>- Automated with final check by SO<br>- Fully automated<br>It should be noted that the level of SO involvement in the final bid selection may differ between the procurement of capacity and energy for a given LFM initiative. |

| | |
|---|---|
| **Network representation in the market** | The type of network representation in the market. We consider the following broad types:<br>- *Advanced network models*<br>- *Simplified network models*<br>- *Representation based on impact factors*<br>- *Market area based on network information*<br>We also check the update frequency of this network representation. |
| **Pricing arrangements** | **Pricing scheme:** Pricing scheme applied in the LFM, such as *pay-as-cleared, pay-as-bid, locational pricing, mixed pricing*, etc. |
| | **Bidding price limits:** Bidding price limits refer to the maximum allowable price or minimum admissible price that can be paid for flexibility. Bidding price limits can apply to the procurement of capacity as well as energy. |
| **Market time unit** | The period for which the flexibility product remuneration price is set. |

*Table 0-5: Classification structure – Cat 3 – Market design – Activation phase*

| Characteristic | Explanation |
|---|---|
| **Mode of activation** | The mode of activation of bids, i.e. manual or automatic. Automatic activation is done automatically and is often referred to as direct control, whereas a manual activation is done at the request of the SO. |
| **Communication requirements** | Method of communication between SO and FSP to trigger activation. |
| **Activation timing** | Timing when an activation signal is sent. Some LFM send explicit activation signals, while for others the publication of the market outcomes entails an implicit activation. A distinction can be made between direct activation and scheduled activation:<br>- In the case of **scheduled activation** the timing of activations is known in advance once the LFM is cleared and no additional activation request is sent.<br>- In the case of **direct activation**, the activation request from the procuring SO can be issued to the FSP at any point in time in the agreed time window activations can occur. |

*Table 0-6: Classification structure – Cat 3 – Market design – Settlement phase*

| Characteristic | Explanation |
|---|---|
| **Baseline methodology(ies)** | Baseline methodology(ies) used for the estimation of the volume of flexibility delivered. We distinguish between the following broad categories of baseline methodologies:<br>- *Meter before/meter after*<br>- *Historical data approach*<br>- *Zero baseline*<br>- *Nomination* |
| **Verification method** | Method applied to verify whether the FSP complies with the promised flexibility delivery. Mostly this is done by comparing the baseline with a measured profile, but other methods – such as the *"drop to" approach* - can also be applied when a realistic baseline is lacking. |
| **Measurement requirement** | Metering requirements for verification and settlement, including whether connection meters and/or submeters are used for verification and settlement. |
| **Measurement time unit** | The smallest time interval over which consumption/injection is measured, recorded, and settled. |
| **Invoicing and payment** | Process for invoicing and payments, i.e. how, when and by whom FSPs are compensated for delivering flexibility services. |
| **Penalties** | Whether penalties are imposed for non-delivery and/or partial delivery, and if so, the methodology used to calculate them. |
| **Aggregation model** | The form of balance correction (for BRPs affected) and financial compensation (for suppliers affected) that were adopted in the context of flexibility delivery for LFM (if any) in case of flexibility delivery through an independent aggregator. |

*Table 0-7: Classification structure – Cat 3 – Market design – Gaming*

| Characteristic | Explanation |
|---|---|
| **Gaming behaviour detected** | Whether strategic behaviour and gaming has been detected by the LFM initiative. |
| **Mitigation actions in place** | The mitigation actions put in place by the LFM initiatives to cope with strategic behaviour. This can include a combination of robust baseline verification, market |

| | |
|---|---|
| | monitoring & audits, penalties for non-compliance, and market/product design improvements. |

*Table 0-8: Classification structure – Cat 4 Governance – Market coordination*

| Characteristic | Explanation |
|---|---|
| **TSO-DSO coordination** | How the coordination between TSO and DSO for the procurement of flexibility and grid security guarantees is arranged. In terms of TSO-DSO coordination during procurement, we distinguish between the following options with increasing levels of coordination:<br>- *Separate SO LFM*<br>- *Sequential DSO-TSO market*<br>- *Common DSO-TSO market* |
| **Bid forwarding** | Mechanisms in place to enable the forwarding of unused (portions of) bids from one market to the next. |
| **DSO-DSO coordination** | Whether and how coordination between DSOs for the procurement of their flexibility services is foreseen. |
| **Coordinated market design** | Alignment of certain parts of the LFM design or certain processes with other markets. |
| **Value stacking** | Measures to enable value stacking across different markets. |

*Table 0-9: Classification structure – Cat 4 Governance – information sharing*

| Characteristic | Explanation |
|---|---|
| **Information prior to market opening** | Information shared before setting up and/or opening the LFM (e.g. areas with grid issues, announcement upcoming tenders, market rules, etc.). A distinction is made regarding whether this information is shared publicly or restricted (e.g., available only to registered FSPs). |
| **Information prior to procurement** | Information shared before the gate closure of the market, such as forecast of the flexibility need (location, amount, etc.), price indication or max price, etc. A distinction is made regarding whether this information is shared publicly or restricted (e.g., available only to prequalified FSPs). |
| **Information after procurement** | Information shared regarding the market outcome in the form of offered volumes, contracted volumes, price information (average prices, max prices, etc.). |

*Table 0-10: Classification structure – Cat 4 Governance – Roles and responsibilities*

| Roles and responsibilities | Explanation |
|---|---|
| *Platform operation* | Entity that operates the market platform. In case there are multiple platforms with each a specific function, a further distinction should be made. |
| *Platform provision* | Entity that developed the market platform. |
| *Flexibility register operation* | Entity that manages the database (register) of flexible energy resources and FSPs. |
| *Market prequalification* | Entity responsible for market PQ. |
| *Product qualification* | Entity responsible for product qualification. |
| *Grid prequalification* | Entity responsible for grid PQ. |
| *Definition of flexibility needs* | Entity that determines the flexibility needs to be procured via the LFM. |
| *Setting the grid/market area* | Entity that defines the market area where flexibility would be procured. |
| *Setting up a merit-order / list of orders* | Entity that prepares the merit-order list or the list of orders. |
| *Matching bids and orders* | Entity that is responsible for matching bids and orders. |
| *Final selection of bids* | Entity that is responsible for the final selection of bids to be procured on the market. |
| *Informing market participants of market outcome* | Entity that informs the market participants of the final outcome of the market. |
| *Sending activation signal* | Entity that sends an activation signal to the selected FSPs and/or flexible resources. |
| *Providing metering data (monitoring)* | Entity responsible for providing metering data as an input for the settlement and verification process. |
| *Validating flexibility delivery* | Entity that validates the flexibility delivery and thus calculates the flexibility actually delivered. |
| *Remunerate/charge FSPs/SOs* | Entity that is in charge for invoicing and payments. |

# Annex 2: Overview of LFM initiatives

## AUSTRIA

Austria has a large number of DSOs of different sizes and one national TSO[23] (APG). The necessity of coordinated flexibility management has therefore already been acknowledged in draft amendments to Austria's Electricity Act (ElWG), but the final legal framework is still under discussion. In Austria, this study covered 2 LFM initiatives which are two country-scale initiatives.


**Industry4Redispatch (I4RD)** was an initiative where the TSO is procuring flexibility from the distribution grid through one platform. The goal of I4RD is to make available previously unused flexibility of industrial customers to the TSO for the provision of redispatch services in compliance with DSO requirements. FSPs are requested to submit their bids DA, and a central capacity management module ensuring that only bids and bid combinations that are not harmful for the DSO grid are available to the TSO when selecting bids. I4RD consisted of a market platform which is linked to an industry-FSP interface and a grid capacity model. While in this project, the focus was on industrial assets, in the future, all connected assets would be allowed to join. The map above shows the locations of all project partners, including FSPs, who participated in the demonstration.

The project **Systemführung 2.0 (SF2.0 project)** is a project in preparation, where not only the TSO but also the DSOs will be procuring flexibility. The SF2.0 project is currently in preparation with larger DSOs, however, when successful, in the long-run the idea is to integrate all DSOs and all assets (including on low-voltage-level). The previous Industry4Redispatch pilot in Austria allowed for the procurement of distribution grid-connected resources by the TSO only. The new SF2.0 foresees the procurement of the most efficient flexibilities with regard to the Austrian-wide national demand, allowing all DSOs and the TSO to procure flexibility through one single LFM, making use of synergies. As such, this project aligns large-scale congestion management services. The product set up aims to harmonise with other markets, for instance by starting after the GCT of the DA market. The initial focus on coordinating flexibility lies therefore on the DA market in a first step. In the long term, the project will take into account all types of flexibility (generation/consumption) and every grid level. In additional steps, later in the project timeline, the coordination process is to be carried out shortly before real time, also allowing for an integration of balancing services. The information listed in the table (see below) expressly refers only to the initial solution (step 1).

[23] Note that there are also two regional TSOs Vorarlberger Übertragungsnetz (VÜN) and Tiroler Übertragungsnetz (TÜN).

## Industry4Redispatch

### General Information

| | | | |
|---|---|---|---|
| Country | Austria | Flex buyer | TSO only |
| Status initiative | Pilot (inactive) (2021-2025) | Involved assets | Mostly industrial assets |

| Market governance | |
|---|---|
| Market platform | Own developed |
| Market operator | TSO |
| Market model | Separate TSO LFM |

| Flexibility need and location | |
|---|---|
| Flex services | Congestion management |
| Grid topology | Meshed |
| Grid level | 110-380 kV |

| Product characteristics | DA redispatch product |
|---|---|
| Product type | Active power |
| Capacity procurement | No |
| Energy procurement | Yes, DA |
| Duration of capacity reservation | NA |
| Duration of energy delivery | 60 minutes |
| Activation | DA |
| Capacity remuneration | No |
| Energy remuneration | Yes, pay-as-bid |

### Market characteristics and supportive processes

| | | | |
|---|---|---|---|
| Product qualification | Ex-ante | Aggregation | Allowed |
| Flexibility register | No flexibility register | Network representation | Simplified network model |
| Baselining method(s) | Nomination baselines | Clearing mechanism | Closed gate auction |

## Step 1: systemführung 2.0 (SF2.0)

| General Information | | | |
|---|---|---|---|
| **Country** | Austria | **Flex buyer** | DSOs and TSO |
| **Status initiative** | Live market (in preparation) | **Involved assets** | All connected assets >500 kW |

| Market governance | |
|---|---|
| **Market platform** | TBD |
| **Market operator** | TBD |
| **Market model** | Common market |

| Flexibility need and location | |
|---|---|
| **Flex services** | Congestion management |
| **Grid topology** | Meshed |
| **Grid level** | >= 110kV |

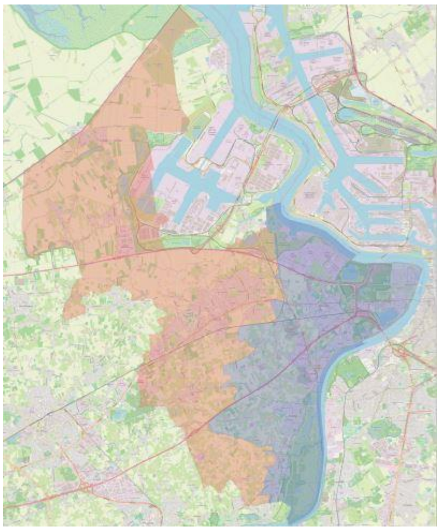
| Product characteristics | Product |
|---|---|
| **Product type** | Active power |
| **Capacity procurement** | No |
| **Energy procurement** | Yes, DA |
| **Duration of capacity reservation** | Timing window specified by SO |
| **Duration of energy delivery** | Min. 60 minutes |
| **Activation** | DA |
| **Capacity remuneration** | No |
| **Energy remuneration** | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register*** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Nomination baselines | **Clearing mechanism** | Closed gate auction |

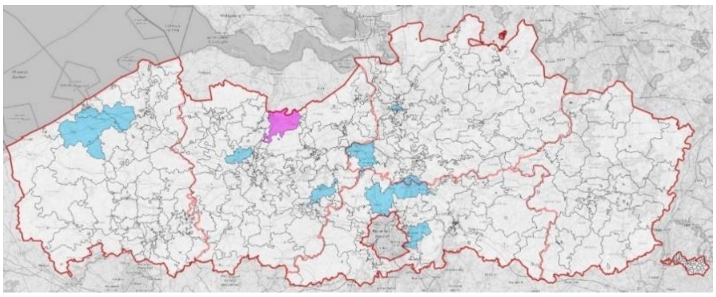
* Flexibility Register: CU data are maintained by the Connection SO and provided to the coordination platform. SP data are managed in the coordination platform.

### BELGIUM

**Belgium** has 4 main DSOs with 3 different regional energy regulators for the three regions (Flanders, Brussels-Capital Region and Wallonia). While there are TSO-DSO and DSO-DSO discussions[24], each DSO individually still has a lot of freedom on whether and how to set up an LFM. This is because, unlike most other countries, a large part of the energy regulation is organised at regional level, implying that implementation and design of LFMs in different Belgian regions can differ. The current status in Belgium is that only in Flanders (the Northern region of the country) there are 2 active LFMs (one for reactive and one for active power) set up and operated by Fluvius, which cover specific pilot locations spread out over the region. In the Walloon region (the Southern part of the country), Ores is also preparing an LFM. Brussels-Capital Region is currently not prioritising market-based solutions as there is a concern that LFMs could suffer from market distortions due to the fact that most congestions are caused by EV-charging (in which the FSPs equal the EV owners causing the congestions).[25]



The purpose of the **Fluvius RP market** is to keep the reactive power flow at any HV/MV substation within a bandwidth. Fluvius incurs financial penalties from the TSO for the additional offtake and/or injection of reactive power. Moreover, the nominal voltage output cannot always be guaranteed if the reactive power exceeds said bandwidth. Adapting the reactive power flow, accordingly, could therefore lead to lower costs and improved reliability. As a result, this LFM relies on a simple service definition in which Fluvius requests a continuous access to setpoint-based reactive power control, within a predefined range (in MVAr) and timeframe (6 months) but without reservation fees. As such, Fluvius receives the right to directly control capacitive or inductive reactive capacity on a real-time basis. FSPs are remunerated based on the effective activation. As shown on the map, the market is tested in a limited geographical area in the vicinity of the Antwerp harbour. Today, the market does not rely on a market platform as the pilot only focusses on a limited scope in time, geography and number of FSPs.



The **Fluvius AP market** aims to decrease congestion management issues in the grid. Today, the Flemish distribution grid is not facing significant congestion problems yet. However, as this might change rapidly over the coming years, and setting up LFMs is considered to have a long learning curve, Fluvius is currently testing an LFM to gain experience. As such, they respond to decretal obligations and prepare themselves to future grid issues. Implementing the NODES market platform, they implement 3 products as discussed in the ID card. With the Maxusage product, the FSP offers Fluvius the ability, for a fee, for specific times and assets in the grid, to limit the power drawn/injected to or below a certain power level. For all times for

[24] https://www.synergrid.be/nl/marktoverleg

[25] https://www.sibelga.be/asset/file/232a106f-4d32-4c89-aa21-1b8503218278

which Fluvius purchases that service, the FSP reduces its power to/below the promised limit (without activation signal). With the LongFlex product, the FSP guarantees, against a reservation fee, to participate with the contracted (reserved) capacity in the activation (ShortFlex) market procedure in the zone during the contracted delivery blocks. Energy procurement and remuneration is therefore arranged through ShortFlex. At the moment of writing this report, it should be noted that a fourth FallBackFlex product is currently in consultation. The picture shows the Flemish zones where currently congestion management services are requested.

Finally, in the Southern part of Belgium, ORES is planning to set up an LFM (**Pic@U**) by the end of 2025. They will start solving grid constraints at higher grid levels but will look as well at LV levels in case results at higher level are considered positive. In the short run, they will kick-off the LFM with an existing market platform as they want to test the concept and establish an experience with market players in the most cost-efficient way. The market will focus on solving problems linked to peak reduction/investment deferral, voltage services (reactive power), maintenance service (in a dynamic way) and congestion problems (in an even more dynamic manner). ORES is also carrying out a project called **'SCOPE'** (Secondary Congestion Option Platform Exchange). Through this marketplace producers with a non-firm connection agreement, could avoid curtailment by activating bids of flexible loads. In this way, consumption would increase, removing the congestion risk without any curtailment. This marketplace is therefore a marketplace where the DSO is not procuring flexibility. Instead, exchanges take place on a peer-to-peer basis between energy producers and FSPs.

# Fluvius Reactive Power Market

| General Information | | | |
|---|---|---|---|
| **Country** | Belgium | **Flex buyer** | DSO only |
| **Status initiative** | Pilot (in operation since Q4 2024) | **Involved assets** | Industrial and large scale generation |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | e-procurement platform (BOSA) | **Flex services** | Voltage control |
| **Market operator** | DSO | **Grid topology** | Radial |
| **Market model** | Separate DSO LFM | **Grid level** | 15,6 kV |

| Product characteristics | Reactive power product |
|---|---|
| Product type | Reactive power |
| Capacity procurement | Yes, timing TBD by DSO |
| Energy procurement | No |
| Duration of capacity reservation | 6 months |
| Duration of energy delivery | When activated by the DSO |
| Activation | Direct control |
| Capacity remuneration | No |
| Energy remuneration | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Not allowed |
| **Flexibility register** | No flexibility register | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Alternative approach | **Clearing mechanism** | Tender |

## Fluvius Local Congestion Market

| General Information | | | |
|---|---|---|---|
| **Country** | Belgium | **Flex buyer** | DSO only |
| **Status initiative** | Pilot (in operation since Q4 2024) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (NODES) | **Flex services** | Congestion management |
| **Market operator** | Independent MO | **Grid topology** | Both radial and meshed |
| **Market model** | Separate DSO LFM | **Grid level** | >10 kV |

| Product characteristics | MaxUsage | ShortFlex | LongFlex |
|---|---|---|---|
| **Product type** | Active power | Active power | Active power |
| **Capacity procurement** | Yes, week ahead | No | Yes, week ahead |
| **Energy procurement** | Yes, week ahead | Yes, ID | Yes, through ShortFlex |
| **Duration of capacity reservation** | Timing window specified by DSO | See LongFlex | Timing window specified by DSO |
| **Duration of energy delivery** | 60 minutes | 60 minutes | 60 minutes |
| **Activation** | Scheduled dispatch | ID | Through ShortFlex |
| **Capacity remuneration** | No | No | Yes, pay-as-bid |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid | No |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Statistical methods; Nomination baselines; Capacity limit approach | **Clearing mechanism** | Tender (MaxUsage, LongFlex); Closed gate auction with open order book (ShortFlex) |

## LFM: Pic@U

| Flexibility need and location | |
|---|---|
| **Country** | Belgium |
| **Flex services** | Congestion management and voltage control |
| **Grid level** | 6-15 kV |
| **Grid topology** | Mix of meshed (95%) and radial (5%) |

| General Information | |
|---|---|
| **Flex buyer** | DSO only |
| **Status initiative** | Pilot (in preparation, kick-off second semester 2025) |
| **Market platform** | Existing (to be decided) |
| **Involved assets** | Both commercial, industrial and generation assets |
| **Market model** | Separate DSO LFM |

## SCOPE

| Flexibility need and location | |
|---|---|
| **Country** | Belgium |
| **Flex services** | Congestion management |
| **Grid level** | 6-15 kV |
| **Grid topology** | Mix of meshed (95%) and radial (5%) |

| General Information | |
|---|---|
| **Flex buyer** | Energy producer |
| **Status initiative** | Pilot (in preparation, first demo expected mid-2026) |
| **Market platform** | Own developed |
| **Involved assets** | Industrial/commercial assets, BESS |
| **Market model** | P2P |

**CYPRUS**

**Cyprus** has one main DSO, who has experimented with an LFM pilot during the **OneNet project**. The LFM is a pilot tested in the H2020 OneNet project. The pilot was set up in response to various grid challenges on the Cypriot island due to high penetration of RES. The market was designed to examine whether such market can contribute to relieving congestions. During the pilot, simulations were done based on active and reactive power, on one specific distribution feeder. In practice, the LFM is not opened in real-life. Market clearing cycles were three hours long.

The surveyed LFM indicated that LFM will not evolve to a live market in the short term, as today the wholesale energy market is not yet fully operational in Cyprus. The introduction of an LFM would only occur after the implementation of the wholesale market. Furthermore, the surveyed LFM indicated that it is to be noted that Cyprus is currently still operated as a non-interconnected island, where efforts are currently being done to link the Cypriot system to the pan-European electricity backbone network and the Israeli network. These challenges are currently given particular attention in the context of the Great Sea Interconnector by the Cypriot and Greek state and the project owner (TSO IPTO).

# Cyprus pilot

Electricity Authority of Cyprus

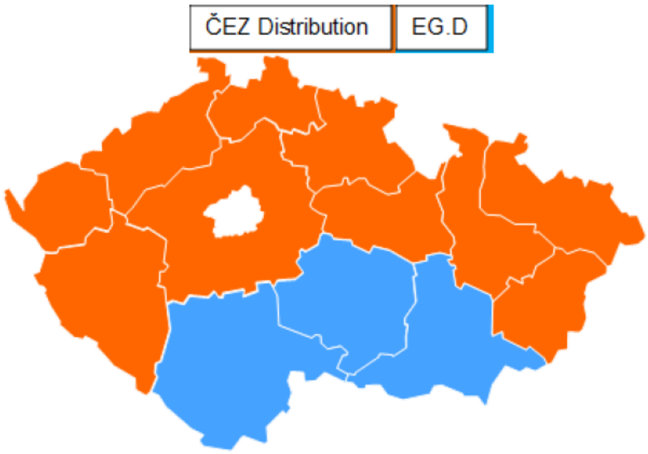
| General Information | | | |
|---|---|---|---|
| **Country** | Cyprus | **Flex buyer** | DSO only |
| **Status initiative** | Pilot (inactive) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Own development | **Flex services** | Congestion management |
| **Market operator** | Not specified in the pilot | **Grid topology** | Radial |
| **Market model** | Separate DSO LFM | **Grid level** | 400V-11kV |

| Product characteristics | Change of active and reactive power (ΔP and ΔQ) | Phase balancing (PB) |
|---|---|---|
| **Product type** | Active and reactive power | Negative and Zero Sequence Current |
| **Capacity procurement** | Yes, timing TBD | Yes, timing TBD |
| **Energy procurement** | Yes, ID | Yes, ID |
| **Duration of capacity reservation** | TBD (market not opened yet, simulations) | TBD (market not opened yet, simulations) |
| **Duration of energy delivery** | 60 minutes | 60 minutes |
| **Activation** | RT (one minute ahead) | RT (one minute ahead) |
| **Capacity remuneration** | Yes, pay-as-cleared | Yes, pay-as-cleared |
| **Energy remuneration** | Yes, pay-as-cleared | Yes, pay-as-cleared |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Not tested in the pilot | **Aggregation** | Allowed |
| **Flexibility register** | No flexibility register | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Meter before/meter after | **Clearing mechanism** | Closed gate auction |

**CZECH REPUBLIC**




The **Czech Republic** has three main DSOs. Two of them (CEZ Distribution and EG.D.) were involved in a pilot implementing an LFM during the **OneNet project**. As a result, the demonstration area comprises of the whole distribution network of the 2 main Czech DSOs. As illustrated in the figure, this covers almost the entire Czech electricity network. The pilot is implemented in real-life conditions, however, today, LFMs are not in operation in the Czech Republic. As indicated by the surveyed LFM, this is primarily due to regulatory constraints. For instance, DSO regulatory framework is still very CAPEX oriented.

During the demo, different modules were set up and tested with the goal to include them in national legislation or to bring them in operation after the demo. On the one hand, most attention was devoted to a Network Traffic Light System (TLS) module which also includes a Flexibility Register. Specifically, the proof of concept developed during the demo, allowed the country to take important steps regarding a common platform for information and data exchange, network TLS and a flexibility register. As of today, the TLS is still operational on a national level where the TSO on a daily basis checks the register when procuring flexibility from the DSO grid.

On the other hand, a Flexibility market trading module was developed. Before the demo, there was no marketplace for non-frequency flexibility services. If relevant, those services were only contracted on a bilateral basis between the DSO and the FSP or provided as mandatory support as defined in the Czech grid code. With this demo, steps were taken to open up markets through updates to Czech grid codes. Some of the updates in the grid codes are based on tests done in the Czech demo via the Trading module, e.g. the LFM design, which is summarised in this ID-card.

# OneNet Demo Czech Republic

## General Information

| | | | |
|---|---|---|---|
| **Country** | Czech Republic | **Flex buyer** | DSO only |
| **Status initiative** | Pilot (inactive in 2024) | **Involved assets** | Industrial assets, charger hubs and generation connected to MV |

## Market governance

| | |
|---|---|
| **Market platform** | Own developed |
| **Market operator** | DSO |
| **Market model** | Separate DSO LFM |

## Flexibility need and location

| | |
|---|---|
| **Flex services** | Voltage control |
| **Grid topology** | Radial |
| **Grid level** | 22 kV |

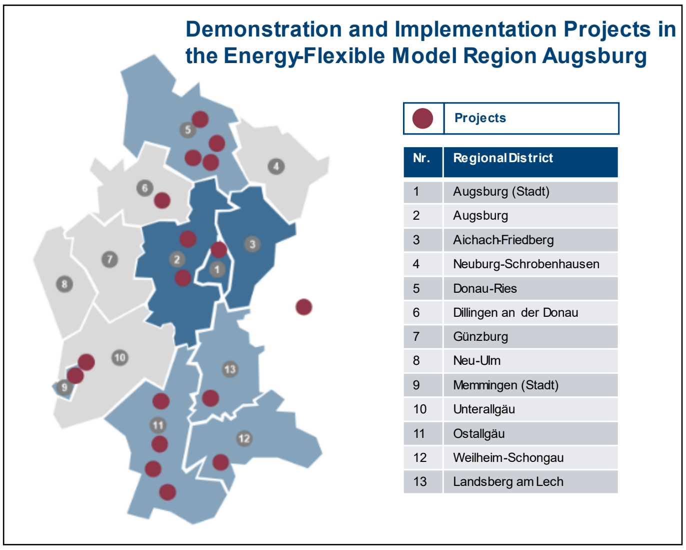
| Product characteristics | Product |
|---|---|
| **Product type** | Reactive power |
| **Capacity procurement** | Yes, months-weeks-day ahead |
| **Energy procurement** | No |
| **Duration of capacity reservation** | Specific hours, e.g. during lunch time due to PV- |
| **Duration of energy delivery** | 60 minutes |
| **Activation** | ID |
| **Capacity remuneration** | Yes, pay-as-bid |
| **Energy remuneration** | Yes, pay-as-bid |

## Market characteristics and supportive processes

| | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Common flexibility register with other markets | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Nomination baseline | **Clearing mechanism** | Closed gate auction |

## GERMANY

**Germany** is the European Member State with the highest number of DSOs (of 800). Traditionally, they manage grid congestion through a cost-based redispatch, rather than market-based mechanisms. Recently, the new §14a EnWG even allows grid operators to temporarily reduce the power consumption of specific "controllable consumer devices" (like EV chargers or heat pumps) in case of grid congestion, without relying on a competitive market. Nevertheless, in parallel, Germany is cautiously testing market-based flexibility procurement via pilot programs. In October 2021, *Redispatch 2.0* was implemented, extending the redispatch regime to include decentralised resources (all generators ≥100 kW, including renewables) at the distribution level. This is still a cost-based system, but it sets the stage for more dynamic solutions. A next-phase concept dubbed *"Redispatch 3.0"* is under development (e.g. the Federal Ministry for Economic Affairs and Energy-funded DEER project) to integrate even smaller units (<100 kW) via aggregators and a digital platform. Another key initiative is the "Nutzen statt Abregeln" ("use instead of curtail") (§13k EnWG) trial launched in October 2024. Under this two-year pilot, TSOs in designated congestion regions can allocate otherwise-curtailed renewable electricity to flexible consumers at a favourable price. DSOs will also be permitted to apply §13k from April 2025[26]. At the DSO level, several pilot projects have tested local flexibility trading on a limited scale. The *enera* pilot (2019–2020) and the Mitnetz EUniversal pilot are just two finalised examples. In the short run, in Bavaria, the Kopernikus project SynErgie/Augsburg pilot project may trial procurement of distribution-level flexibility to manage local network constraints. The Reallabore Gesetz enables experimental projects, as is intended in the Augsburg pilot project, to test innovative, often market-based approaches in a real-world environment, even if those approaches don't yet fit within the existing regulatory framework.




The **Augsburg** pilot is very briefly discussed in the ID-card below as the pilot is still in preparation. The Kopernikus project SynErgie explores how industrial energy demand can dynamically adapt to fluctuating renewable generation. In this context, the Energy-Flexible Model Region Augsburg serves as a real-world pilot project in which, among various other aspects, it is intended to explore how local flexibility can support grid stability without compromising industrial processes. For this purpose, the Augsbura pilot aims to implement a LFM in the coming years, focusing on ST procurement of demand-side flexibility to alleviate local grid congestion. Market participants will offer flexibility through structured processes, supported by intelligent metering and automation systems. The targeted grids are not fully defined yet, but flexibility services will be deployed across different voltage levels (HV, MV and LV). Although the exact market design is still in development, current planning envisions a two-stage model: Reservation stage, where flexible capacity is contracted; Activation stage, where flexibility is called via day-ahead or intraday auctions priced in €/MWh. Coordination between DSOs and TSOs is integral, both in bid validation and in auction clearing algorithms. The LFM is designed to preserve the single German bidding zone while

[26] https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/EN/2024/20240415_NSA_Konsultation.html

complementing it with locational price signals at the distribution level, in line with BMWK policy priorities. The pilot is supported by a transdisciplinary network, including grid operators, academia, and local industry. Findings from the Augsburg model are expected to inform broader regulatory developments around decentralized congestion management and local flexibility activation.

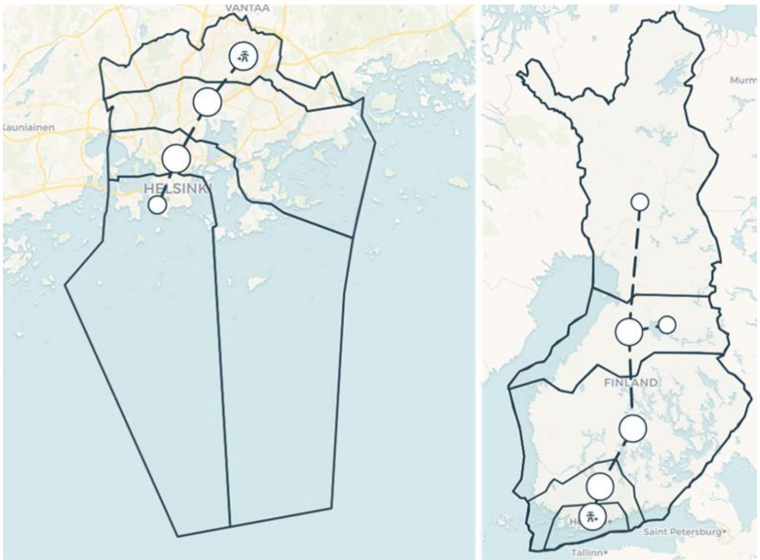
## Augsburg LFM

| General Information | | | |
|---|---|---|---|
| **Country** | Germany | **Flex buyer** | DSO and TSO |
| **Status initiative** | Pilot (in preparation) | **Involved assets** | TBD, most likely energy-intense industrial assets |
| **Market governance** | | **Flexibility need and location** | |
| **Market platform** | Existing (EPEX SPOT) | **Flex services** | Congestion management |
| **Clearing mechanism** | Closed gate auction | | |

aa

## FINLAND

**Finland** has about 10 high-voltage DSOs, and almost 80 low and medium voltage DSOs. The country only has one TSO. In terms of LFMs, the country has no other live LFM pilot other than the FinFlex common DSO-TSO market. As the TSO is involved, the market overarches the entire country. However, as only one DSO is involved, services by the DSO are only procured in the grid operated by this DSO. The future ambition is for multiple DSOs to join the LFM. In the past, they already gained experience through a OneNet demo. Both the OneNet demo and the current FinFlex LFM are covered in this study and presented in the ID-cards below.




**FinFlex** is developed after previous OneNet experiences. The goal is to run this pilot project directly as a fully operational market. In the market, both the TSO and the DSO will buy flexibility starting from Q1 2025 in a sequential market where the DSO procures right before the TSO. Flexibility procurement by both the TSO and the DSO will be done through the same platform. As such, in this project, it is aimed to acquire new flexible resources, especially such assets that cannot meet the technical requirements of the TSO ancillary service markets. In addition, SOs are to gain experience in acquiring congestion management services from all levels of the grid to respond to bottlenecks in high voltage grids. In the future, the idea is to attract multiple DSOs to the same market. The project aims to prepare for the requirements of the future NC DR. The map on the left shows the DSO grid, while the map on the right shows the TSO grid. The white dots are virtual grid nodes where the actual trading takes place, and the areas are visual representation of the coverage of a particular node. In total, 2 products are being procured, among which one capacity product which contains an obligation to bid in the energy product. Originally, they considered the energy product as two separate products due to the sequential timings. However, today, it is considered as one single product.

**The Finnish OneNet demo** was set up originally as the Finnish grid is seeing increasing congestion management needs on both DSO and TSO grids due to rapid electrification. The LFM market was simulated to test the functionalities developed during the Northern OneNet demo. The main goal of the Finnish demonstration was to test the market-based and coordinated flexibility procurement with relevant network situations for the Finnish environment to learn how the congestions can be solved using flexibility and how the combination of flexibility from DSO and TSO networks interacts. The developed platform solution with the optimisation algorithm provided a novel tool to investigate the different flexibility use cases. Specifically, two existing market platforms (namely the mFRR market platform operated by Fingrid and the intraday platform operated by Nord Pool) were adapted to work with a TSO-DSO coordination platform. The coordination platform made the procurement decisions and communicated them back to the market platforms, which then concluded the trades. As discussed in the ID-card, 2 products were procured on the platform. The starting point for the design of the Northern demonstrator was the actual flexibility needs of the system operators. Based on these needs both the standard products and the used network scenarios were designed. To keep the number of products as low as possible and by relying on existing products like mFRR or intraday trading product, they ensured that the same product can be used by both TSO and DSO. Testing the overall process in the Finnish demonstration was accompanied by flexibility activations from real resources.

| FinFlex | | | |
|---|---|---|---|
| **General Information** | | | |
| **Country** | Finland | **Flex buyer** | DSO and TSO |
| **Status initiative** | Pilot (in operation since 2025) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (NODES) | **Flex services** | Congestion management |
| **Market operator** | Independent MO | **Grid topology** | Meshed |
| **Market model** | Sequential market (DSO first, TSO second) | **Grid level** | 400 kV (TSO), 110 kV (DSO), but also procured from lower grid voltages |

| Product characteristics | Capacity product | Energy product prior to day ahead market | Energy product post day ahead market |
|---|---|---|---|
| **Product type** | Active power | Active power | Active power |
| **Capacity procurement** | Yes, timing to be decided by SO | No | No |
| **Energy procurement** | Yes, DA | Yes, DA | Yes, ID |
| **Duration of capacity reservation** | For each hour separately | NA | NA |
| **Duration of energy delivery** | 60 minutes | 60 minutes | 60 minutes |
| **Activation** | DA | DA | ID |
| **Capacity remuneration** | Yes, pay-as-bid | No | No |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Statistical methods | **Clearing mechanism** | Closed gate auction (all DA-products) and continuous market (ID product) |

## OneNet Northern Demonstration Finland

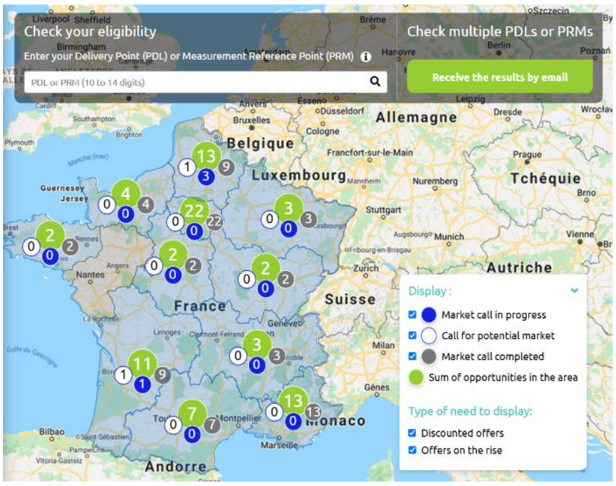
| General Information | | | |
|---|---|---|---|
| **Country** | Finland | **Flex buyer** | DSO and TSO |
| **Status initiative** | Pilot (inactive since 2023) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing LFM (Nordpool); Own developed (TSO-DSO | **Flex services** | Congestion management |
| **Market operator** | Not defined in the project | **Grid topology** | Radial and meshed |
| **Market model** | Common market | **Grid level** | 110-440 kV (TSO), 20 kV (DSO) |

| Product characteristics | Near Real-time active energy | Short-term active energy |
|---|---|---|
| **Product type** | Active power | Active power |
| **Capacity procurement** | No | No |
| **Energy procurement** | Yes, ID | Yes, ID |
| **Duration of capacity reservation** | NA | NA |
| **Duration of energy delivery** | 15 minutes | 60 minutes |
| **Activation** | ID | ID |
| **Capacity remuneration** | No | No |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Common flexibility register with other markets | **Network representation** | Advanced network model |
| **Baselining method(s)** | Statistical methods; Nomination baselines | **Clearing mechanism** | Closed gate auction (NRT-P-E ) and continuous market (ST-P-E ) |

**FRANCE**




**France** has one main DSO, **Enedis**, who operates a flexibility market over the 95% of the country, covering MV substations and feeders where local services are needed. The French distribution grid has rather low voltage levels compared to other countries (20 kV and below). With its LFM, Enedis seeks opportunities of local flexibility able to provide an alternative to traditional means through different calls for tenders only when and where a market based local service can be of use: (1) Local flexibility for an immediate and ST operational need (2) Local flexibility to host more renewables (3) Local flexibility to defer a reinforcement investment. As discussed below, they procure two different types of products through their market platform (of which a visualisation is shown on the picture). They have both a product with and a product without reservation. In case of a product without capacity reservation, the FSP has the option to refuse the activation request by the DSO without penalty.

## Appel d'offres pour des Flexibilités Locales marché

| General Information | | | |
|---|---|---|---|
| Country | France | Flex buyer | DSO only |
| Status initiative | Live market (in operation since 2020) | Involved assets | All connected assets |

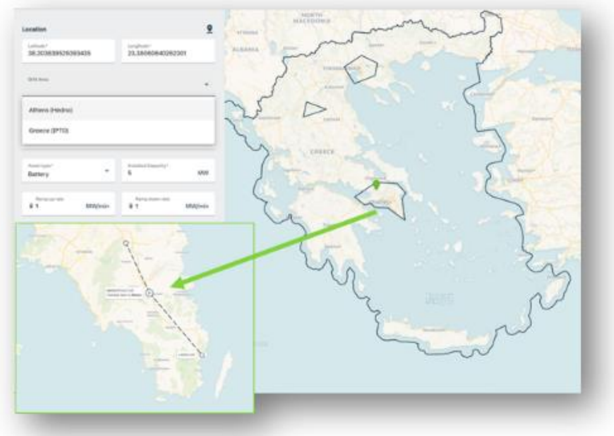
| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market platform | Own developed | Flex services | Congestion management |
| Market operator | DSO | Grid topology | Radial |
| Market model | Separate DSO LFM | Grid level | <20 kV |

| Product characteristics | Product without capacity reservation | Product with capacity reservation |
|---|---|---|
| Product type | Active power | Active power |
| Capacity procurement | No | Yes, year to months ahead |
| Energy procurement | Yes, minutes ahead* | No |
| Duration of capacity reservation | NA | Timing window specified by DSO |
| Duration of energy delivery | Min. 30 minutes | Min. 30 minutes |
| Activation | Min. 25 minutes ahead | Min. 25 minutes ahead |
| Capacity remuneration | No | Yes, pay-as-bid |
| Energy remuneration | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Ex-ante | Aggregation | Allowed |
| Flexibility register | Flexibility register on the level of LFM | Network representation | Market area based on network information |
| Baselining method(s) | Statistical methods, capacity limit approach, zero baseline, meter before/meter after, nomination baselines and other methods. | Clearing mechanism | Tender |

**GREECE**

In **Greece**, there is only one DSO (HEDNO). HEDNO and IPTO (the TSO) are preparing the setup of an LFM in which both will have access to the same flexibility assets connected at the distribution level. The LFM was initiated in response to the growing challenges of the distribution grid and the opportunity provided by the OPENTUNITY project. There was no regulatory push. Furthermore, in Greece, as part of the FEVER project, simulations were being done by HENEX (Hellenic Energy Exchange S.A.). The Greek Simulator focuses on the simulation of newly developed market tools and mechanisms. The objective of the conducted tests is to simulate the operation of electricity markets that incorporate novel flexibility-related services. It introduces the role of the FSP in the markets it operates. Both the simulation and the HEDNO/IPTO LFM are part of this study and are presented below.



The **Greek Opentunity demo** of HEDNO and IPTO is a pilot in preparation and situated in Mesogia, in the southeastern part of Attica, near Athens. The Markopoulo Substation is positioned at the boundaries between the transmission and distribution systems. It transforms voltage from the 150kV (part of TS) level to the 20kV level (part of DS). The substation is designed to provide power to 2812 houses and 123 commercial buildings. The goal of the pilot is to conduct LFM testing with the help of Flexibility Market Operator NODES, which operates the Local Market and manages interactions between the DSO, TSO and flexibility providers. Furthermore, the aim is to showcase TSO/DSO collaboration through improved data exchange by utilising a federated data space infrastructure. This ensures efficient and cybersecure sharing of data, leading to a more synergistic grid management between medium-voltage (MV) and high-voltage (HV) lines. The project is part of the Horizon Europe OPENTUNITY project and currently preparing the pilot set-up. The figure above illustrates the location of the pilot and the generic set-up and divisions among partners.

The **Greek FEVER HENEX Simulator** focuses on the simulation of newly developed market tools and mechanisms. The objective of the conducted tests is to simulate the operation of electricity markets that incorporate novel flexibility-related services. It introduces the role of the Flexibility Servicer Provider in the markets it operates. By doing so, it expands the existing Greek regulatory framework on frequency services and demand side response on the transmission grid level to the distribution networks. The target is to provide an adoptable solution for other European electricity markets. The use cases range from day-ahead over intra-day to real-time trading mechanisms. The aim is to test market mechanisms for incentivising flexibility or other market tools to mitigate problems of the distribution system network. The simulation tests address the business cases of all stakeholders, highlighting the scalability of the proposed market structure in future electricity markets. The demonstrator anticipates that it will foster the design of a well-functioning electricity market, enhance the cooperation among SOs and develop new business cases for all stakeholders. Involved is among other HEnEx, which is the Nominated Electricity Market Operator (NEMO) for the Greek Bidding Zone. The simulation is part of the European Horizon 2020 FEVER project.

# HENEX Greece FEVER demo

| General Information | | | |
|---|---|---|---|
| **Country** | Greece | **Flex buyer** | DSO only |
| **Status initiative** | Finalized simulations | **Involved assets** | Industrial assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Own developed (LFM clearing algorithm by HEnEx) | **Flex services** | Congestion management, voltage control and deviations |
| **Market operator** | Independent MO | **Grid topology** | Both radial and meshed |
| **Market model** | Separate DSO LFM | **Grid level** | 20 kV |

| Product characteristics | Active power trading between DSO-FSP | Reactive power trading between DSO-FSP | Active power trading between two FSPs |
|---|---|---|---|
| **Product type** | Active power | Reactive power | Active power |
| **Capacity procurement** | No | No | No |
| **Energy procurement** | Yes, ID (one hour before delivery) | Yes, ID (one hour before delivery) | Yes, ID (one hour before delivery) |
| **Duration of capacity reservation** | NA | NA | NA |
| **Duration of energy delivery** | 15 minutes | 15 minutes | 15 minutes |
| **Activation** | ID (one hour before delivery) | ID (one hour before delivery) | ID (one hour before delivery) |
| **Capacity remuneration** | No | No | No |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Not tested | **Aggregation** | Allowed |
| **Flexibility register** | No flexibility register | **Network representation** | Impact factors |
| **Baselining method(s)** | Not tested | **Clearing mechanism** | Continuous market |

## HEDNO, IPTO Greek demo

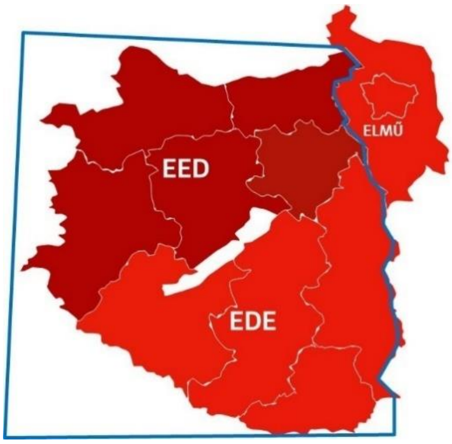
| General Information | | | |
|---|---|---|---|
| Country | Greece | Flex buyer | DSO and TSO |
| Status initiative | Pilot (in preparation) | Involved assets | Mostly residential assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market platform | Existing [NODES] | Flex services | Congestion management, balancing |
| Market operator | Independent MO | Grid topology | Radial and meshed |
| Market model | Common market | Grid level | 20-150 kV |

| Product characteristics | NODES ShortFlex |
|---|---|
| Product type | Active power |
| Capacity procurement | No |
| Energy procurement | Yes, 2 hours ahead |
| Duration of capacity reservation | NA |
| Duration of energy delivery | Min. 15 minutes |
| Activation | Upon matching, 2 hours ahead |
| Capacity remuneration | No |
| Energy remuneration | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Not specified yet | Aggregation | Allowed |
| Flexibility register | Common flexibility register with other markets | Network representation | Market area based on network information |
| Baselining method(s) | Alternative approach | Clearing mechanism | Closed gate auction |

**HUNGARY**




**Hungary** has six DSOs, three of which belong to the E.ON Group. E.ON is currently establishing the Flex.ON LFM in collaboration with two of its DSOs, i.e. EDE and EED. In the future, the third DSO, ELMÜ, is also expected to join the market. This LFM is launched through the **Flex.ON program**, kicked off in 2022. The program consists of different developments linked to ensuring stability and flexibility of the electricity network through innovative ways, making the grid smarter. One of the elements being tested is a flexibility platform that does not only encompass a LFM, but that also includes a full optimisation process, accounting for FCAs, voltage and flow conditions in the whole network, and different types of forecasts. The project has received funding awarded by the National Research, Development and Innovation Office (Nemzeti Kutatási, Fejlesztési és Innovációs Hivatal (NKFIH)). As visualised on the map, currently two DSO-grids are covered (EED and EDE). The ELMU grid will be added later to the project.

# Flex.on Local Flexibility Market

| General Information | | | |
|---|---|---|---|
| Country | Hungary | Flex buyer | Multiple DSOs |
| Status initiative | Pilot (in preparation, to be opened in 2025) | Involved assets | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market operator | DSO | Flex services | Congestion management |
| Market model | Common market | Grid topology | Radial and Meshed |
| Market platform | Own developed | Grid level | 11-132 kV |

| Product characteristics | +Pmax (Feed-in max) | -Pmin (offtake minimum) | -Pmax (offtake max) | +Pmin (Feed-in minimum) |
|---|---|---|---|---|
| Product type | Active power | Active power | Active power | Active power |
| Capacity procurement | No | No | No | No |
| Energy procurement | Yes, DA | Yes, DA | Yes, DA | Yes, DA |
| Duration of capacity reservation | NA | NA | NA | NA |
| Duration of energy delivery | 60 minutes | 60 minutes | 60 minutes | 60 minutes |
| Capacity remuneration | No | No | No | No |
| Activation | DA | DA | DA | DA |
| Energy remuneration | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Ex-ante | Aggregation | Only assets behind same connection point |
| Flexibility register | Flexibility register on the level of LFM | Network representation | Impact factors |
| Baselining method(s) | Alternative approach | Clearing mechanism | Closed gate auction |

## IRELAND

**Irelands'** Climate Action Plan (CAP) targets 20-30% flexible demand by 2030 [132]. As a result, the key DSO ESB Networks is planning a first medium-term flexibility procurement round of 109 MW across 14 different locations (see figure), followed by subsequent rounds up to 500 MW. This market opening is planned for 2025 but was preceded by CRU stakeholder consultations on ESBN's Demand Flexibility Product Proposal [133].


The product being procured is a medium-term Demand Flexibility Product, which is currently out to tender. It is designed for flexibility delivery under a LT (15-year) contract. FSPs will be required by the DSO to operate the flexible assets they represent within a defined operating envelope. This envelope spans 24 hours and sets upper and lower MW limits for export and/or import from the grid. By adhering to these limits when participating in existing wholesale markets, the flexible assets will support the distribution network.

## Irish Demand Flexibility Product

| General Information | | | |
|---|---|---|---|
| **Country** | Ireland | **Flex buyer** | DSO only |
| **Status initiative** | Live market (in preparation, first delivery foreseen in 2028) | **Involved assets** | All type of assets, but some threshold limits |

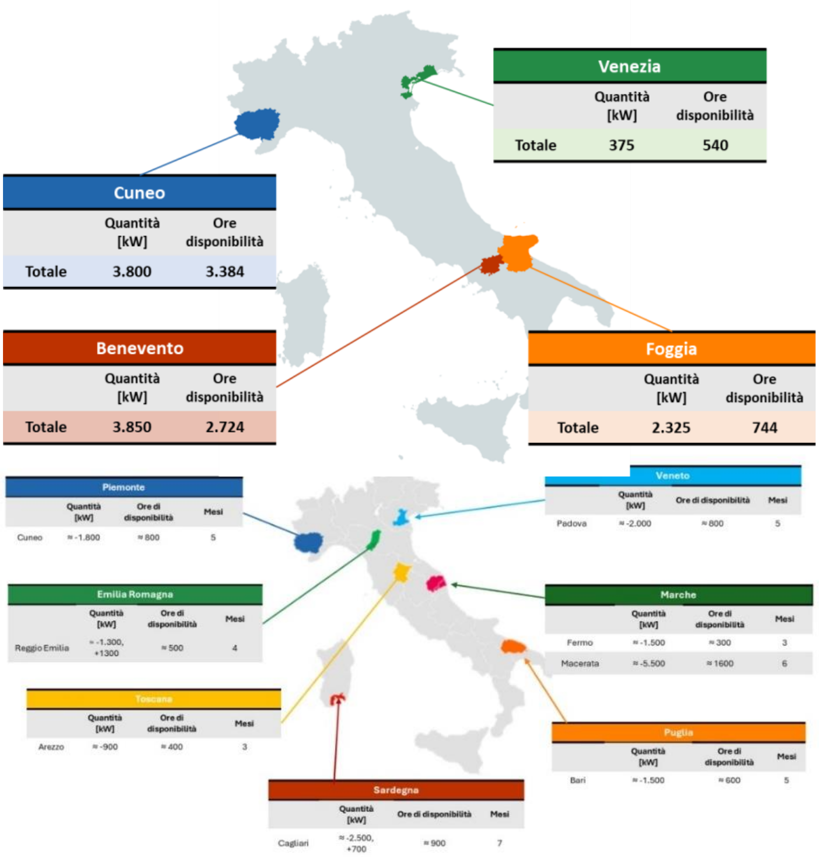
| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (to be procured + combination wholesale markets) | **Flex services** | Congestion management |
| **Market operator** | DSO | **Grid topology** | Mostly radial |
| **Market model** | Separate DSO LFM | **Grid level** | 38-110 kV |

| Product characteristics | Demand Flexibility Product |
|---|---|
| **Product type** | Active power |
| **Capacity procurement** | Yes, 2-3 years in advance |
| **Energy procurement** | No |
| **Duration of capacity reservation** | Up to 15 years |
| **Duration of energy delivery** | 30 minute intervals over a 24 hour period |
| **Activation** | Two days ahead |
| **Capacity remuneration** | Yes, floor and share mechanism |
| **Energy remuneration** | No |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Not allowed |
| **Flexibility register** | No flexibility register | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Alternative approach | **Clearing mechanism** | Tender |

## ITALY

There are about 140 DSOs in Italy. **Italy** has multiple LFM pilots, which are testing with real trades. Specifically, GME the national market platform in Italy, developed together with Areti, one architecture in which all DSOs can connect their internal technical platforms to a market interface and platform. A standardised communication is used to ensure all DSOs can use the platform and the idea is to implement the platform everywhere in Italy. RomeFlex (in Rome) and MindFlex (in Milan) are two areas where the platform is currently being implemented. However, DSOs are free to choose their own platform, and the EDGE project is for instance one example of an LFM which implements a commercial LFM platform in multiple Italian regions.




The **EDGE** (Energy from Distributed Resources for the Management of the E-Distribuzione Network) project represents Italy's first structured initiative to implement an LFM at the distribution level. Spearheaded by E-Distribuzione, it aligns with ARERA's (Italy's regulatory authority) deliberations on procuring local flexibility services from Distributed Energy Resources (DERs). This initiative starts a sandbox experience to define future national rules on local flexibility services. In the 2024-2025 expansion, EDGE has been extended to Piemonte, Veneto, Emilia-Romagna, Marche, Toscana, Sardegna, and Puglia, covering critical network areas identified through load growth forecasts and congestion risk analysis. The project structure leverages a technology-neutral approach, integrating generation, storage, demand response, and electric vehicle charging as flexibility providers. The maps show EDGE's 2024 procurement plan on the top, and the 2025 procurement plan at the bottom.

**The RomeFlex LFM** has been implemented by ARETI (the DSO) and GME (the LMO) as a follow-up on the European PlatOne Project and other initiatives, and in line with Italian regulation. The RomeFlex LFM includes forward auctions and daily spot markets, addressing ARETI's specific needs for the following day. During the DA session, both FSPs that participated in the forward auctions and all other FSPs will have the opportunity to join, increasing market liquidity. In the future, it may be extended to include ID spot markets. Its open and modular architecture allows the LFM to be replicated across all Italian territories managed by DSOs, with options for customised products, as was done in the MindFlex LFM. In addition, the platform has one unique interface for all the DSOs, decreasing transaction costs for FSPs who join multiple markets.

Finally, the **MiNDFlex** LFM adopts the ARETI/GME market scheme as described in RomeFlex. It is a pilot project aimed at procuring flexibility for the Milan electricity grid. The increasing electrification of consumption and the integration of distributed generation are leading to greater electricity flows in the distribution network, making them harder to predict. This challenge is the primary driver for acquiring flexibility. All grid users who wish to make their flexibility available will be able to do so through the market, which was first initiated in 2024. The pilot falls within the scope of ARERA's resolutions 372/2023 and 121/2024/R/eel.

## EDGE

e-distribuzione

| General Information | | | |
|---|---|---|---|
| Country | Italy | Flex buyer | DSO only |
| Status initiative | Pilot (in operation since 2023) | Involved assets | All connected assets |

| Market governance | |
|---|---|
| Market platform | Existing (PICLO) |
| Market operator | Independent MO |
| Market model | Separate DSO LFM |

| Flexibility need and location | |
|---|---|
| Flex services | Congestion management |
| Grid topology | Meshed |
| Grid level | <20 kV |

| Product characteristics | Servizi Ancillari Locali |
|---|---|
| Product type | Active power |
| Duration of delivery | Min. 15 minutes |
| Capacity procurement | Yes, week to month ahead |
| Energy procurement | No |
| Activation | 60 minutes before delivery |
| Capacity remuneration | Yes, pay-as-bid |
| Energy remuneration | Yes, pay-as-bid |
| Capacity reservation duration | One season |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Ex-ante | Aggregation | Allowed |
| Flexibility register | Flexibility register on the level of LFM | Network representation in the | Market area based on network information |
| Baselining method(s) | Meter before/meter after | Clearing mechanism | Tender |

# RomeFlex

## General Information

| | | | |
|---|---|---|---|
| Country | Italy | Flex buyer | DSO only |
| Status initiative | Pilot (in operation since 2024) | Involved assets | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market platform | Existing (GME-market scheme) | Flex services | Congestion management |
| Market operator | Independent MO | Grid topology | Meshed |
| Market model | Separate DSO LFM | Grid level | 230V-20kV |

| Product characteristics | MLT-Forward market MLT-Flex | MLP-Spot market MGP Flex |
|---|---|---|
| Product type | Active power | Active power |
| Capacity procurement | Yes, adjustable (f.i. year(s) ahead) | No |
| Energy procurement | Yes, via direct activation by DSO | Yes, DA |
| Duration of capacity reservation | Timing window specified by DSO | NA |
| Duration of energy delivery | Min. 15 minutes | Min. 15 minutes |
| Activation | DA | DA |
| Capacity remuneration | Yes, pay-as-bid | No |
| Energy remuneration | Yes, pay-as-bid | Yes, pay-as-bid |

## Market characteristics and supportive processes

| | | | |
|---|---|---|---|
| Product qualification | Ex-ante | Aggregation | Allowed |
| Flexibility register | Common flexibility register with other markets | Network representation | Market area based on network information |
| Baselining method(s) | Statistical methods | Clearing mechanism | Closed gate auction |

# MindFlex

| General Information | | | |
|---|---|---|---|
| **Country** | Italy | **Flex buyer** | DSO only |
| **Status initiative** | Pilot (in operation since 2024) | **Involved assets** | All connected |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (GME-market scheme) | **Flex services** | Congestion management |
| **Market operator** | Independent MO | **Grid topology** | Meshed |
| **Market model** | Separate DSO LFM | **Grid level** | 23 kV |

| Product characteristics | MLT-Flex (forward flex market) |
|---|---|
| **Product type** | Active power |
| **Capacity procurement** | Yes (timing TBD by DSO) |
| **Energy procurement** | Yes |
| **Duration of capacity reservation** | Timing window specified by DSO |
| **Duration of energy delivery** | Min. 15 minutes |
| **Activation** | One hour ahead |
| **Capacity remuneration** | Yes, pay-as-bid |
| **Energy remuneration** | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Alternative approach | **Clearing mechanism** | Closed gate auction |

## LATVIA

In **Latvia**, the largest DSO (covering 99% of the country) is setting up an LFM, including its own in-house market platform and a third-party flexibility activation platform. They aim to run their first pilot in 2026 and are currently working out their product and market design. The **Latvian LFM** is being set-up mostly in anticipation for demand increase due to electrification. Meanwhile, new generation connections are resolved with FCA. There is no existing regulation for LFMs in Latvia yet, and the pilot they are setting up is therefore part of a regulatory sandbox project. The current project expects to set up a market with an in-house developed market platform on which a ST flexibility product is procured. So far it seems that securing demand-side flexibility is more difficult than expected. For the pilot project, they therefore choose areas where there are assets rather than where the congestion is most likely to occur. Lack of aggregator readiness can be explained by the fact that until this year, Baltic TSOs were connected to BRELL (Russia) and never in the past had to regulate frequency (no FCR, aFRR, or mFRR markets until this year).

### LATVIA LFM pilot

ST FLEX

| General Information | | | |
|---|---|---|---|
| Country | Latvia | Flex buyer | DSO only |
| Status initiative | Pilot (in preparation for 2026) | Involved assets | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market platform | Own developed | Flex services | Congestion management |
| Market operator | DSO | Grid topology | Radial |
| Market model | Separate DSO LFM | Grid level | 20kV (MV) & 0.4kV (LV) |

| Product characteristics | ST FLEX |
|---|---|
| Product type | Active power |
| Capacity procurement | Yes, once a year |
| Energy procurement | Yes, once a year |
| Duration of capacity reservation | 1 year contract duration |
| Duration of energy delivery | Max. 4 hours |
| Activation | DA |
| Capacity remuneration | Yes, pay-as-bid |
| Energy remuneration | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Ex-ante | Aggregation | Allowed |
| Flexibility register | Flexibility register on the level of LFM | Network representation | Market area based on network information |
| Baselining method(s) | Statistical methods | Clearing mechanism | Closed gate auction |

**LITHUANIA**

**Lithuania** has one key DSO which operates 99% of the country's distribution grid. The country gained experience regarding LFMs through the **OneNet project** which helped them to establish some elements of the required regulation on the topic. Through the OneNet project, the main Lithuanian DSO ESO prepared for the set-up of LFMs. Through the demo, they prepared for the potential roll-out of future LFM, both from a regulatory point of view, and from a market and infrastructure point of view. As a result, today, theoretically, they can procure flexibility services (both capacity and energy). However, until today, the market is still inactive as there is currently no significant need for flexibility. This is because Lithuania does not have highly critical grid congestion areas at the moment. As a result, no LFM is active in Lithuania. Currently, the platform implemented is the national public tender platform which serves for all public procurements, and which is therefore not dedicated specifically for flexibility services only. In the future, they might evolve towards another procurement platform. Additionally, ESO still needs to develop internal tools to ensure full transparency on grid congestion and improve its ability to forecast congestion issues. Nevertheless, some pilot projects have already been carried out, and further initiatives are planned in the near future.

## Lithuanian LFM

eso

| General Information | | | |
|---|---|---|---|
| **Country** | Lithuania | **Flex buyer** | DSO only |
| **Status initiative** | Live Market (but inactive) | **Involved assets** | All connected assets |

| Market governance | |
|---|---|
| **Market platform** | Existing |
| **Market operator** | DSO |
| **Market model** | Separate DSO LFM |

| Flexibility need and location | |
|---|---|
| **Flex services** | Congestion management |
| **Grid topology** | Depends on the need, TBD |
| **Grid level** | Depends on the need, TBD |

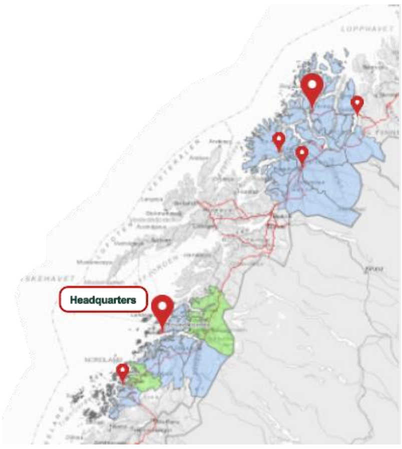
| Product characteristics | Long-term active energy product |
|---|---|
| **Product type** | Active power |
| **Capacity procurement** | Yes, months to year ahead |
| **Energy procurement** | Yes |
| **Duration of capacity reservation** | Timing window specified by DSO (e.g. during one month, at 18h) |
| **Duration of energy delivery** | 1-12 hours |
| **Activation** | DA |
| **Capacity remuneration** | Yes, pay-as-bid |
| **Energy remuneration** | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | No flexibility register | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Statistical methods | **Clearing mechanism** | Depends on the market platform to be chosen |

## NORWAY

**Norway** is a country with more than 100 smaller DSOs. Some of these have set up LFMs in the past or are still running them. The largest one is the Norflex project, which is now extended into the Euroflex project, running from 2023-2026. With 8 of the larger Norwegian DSOs, this is a sizeable LFM, approximately covering two-thirds of meter points in Norway. The goal of the project is to scale the DSO flexibility market and prepare for a BaU (Business as Usual) market from 2027 onwards. Furthermore, there are other smaller initiatives such as FlexLab. Finally, a smaller Norwegian project which participated in this study is the Smart Senja market, located in the Northern part of the Norwegian distribution grid. This study covers the Smart Senjan LFM and the Euroflex initiative and discusses them below in more detail.

The **Smart Senja** market is tested in an area with long and older distribution radials where the highest loads are from two fisheries at the end of the line. In addition, the load of the fisheries coincides with the Norwegian peak heat demand period. The fishery-load was almost half of the load of the community, implying that other flexibility tools appeared to be more successful in terms of flexibility delivery (e.g. micro grid, batteries, etc.) than the LFM through which it was hard to find additional flexibility. The test LFM was ran for 4 trading periods and is currently not continued. However, the project created a good base to kick-off new LFM in other regions if there is a need for it.





**Euroflex** is a market funded by the Norwegian agency Enova and it is launched as a continuation and expansion of the NorFlex project. 8 Norwegian DSO's participate in the project (Tensio, Linja, BKK, Fagne, Lnett, Glitre nett, Elvia and Norgesnett). These 8 DSOs constitute approximately 2/3 of meter points in Norway. In March 2024, Enova, a Norwegian government enterprise supporting the transition to a low-emission society, allocated NOK 100 million to Euroflex. This funding underscores the project's significance and its alignment with national energy and climate objectives. The goal of the project is to scale the DSO flexibility market and prepare for a BaU market from 2027. The primary goal of Euroflex is to unlock, utilise, and scale consumer flexibility by facilitating market-based transactions that allow consumers to adjust their electricity consumption in response to grid demands. This approach aims to alleviate grid congestion during peak periods, reduce the need for extensive infrastructure investments, and integrate a higher share of renewable energy sources into the power system. Euroflex operates the NODES platform through which the products below are procured. For a limited period of time, bids from qualified FSPs were forwarded to Statnett's mFRR market on a voluntary basis (NorFlex project). Euroflex procures 3 types of products: ShortFlex, LongFlex and MaxUsage. In LongFlex, the FSP guarantees to participate with the contracted (reserved) capacity in the activation (ShortFlex). Energy procurement is therefore arranged through ShortFlex. With the MaxUsage product, the FSP offers the DSO the ability, for specific times and assets in the grid, to limit the power drawn/injected below a certain power level. For all times for which the DSO purchases that service, the FSP needs to reduce its power (without activation signal). In In the cases where there is capacity procurement, it is specified in the tender how long ahead capacity is procured. The market rules set no limit on the duration of a reservation contract or on how long before activation it can be entered. In practice, most contracts are seasonal, tenders for the next season (i.e. with delivery up to 18 months after).

## Smart Senja

Arva

| General Information | | | |
|---|---|---|---|
| Country | Norway | Flex buyer | DSO only |
| Status initiative | Pilot (inactive since 2024) | Involved assets | Mostly industrial and residential assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market platform | Existing (NODES) | Flex services | Congestion management and voltage control |
| Market operator | Independent MO | Grid topology | Radial |
| Market model | Separate DSO LFM | Grid level | 22 kV |

| Product characteristics | ShortFlex |
|---|---|
| Product type | Active power |
| Capacity procurement | No |
| Energy procurement | Yes, ID |
| Duration of capacity reservation | NA |
| Duration of energy delivery | 60 minutes |
| Activation | Direct control |
| Capacity remuneration | No |
| Energy remuneration | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Not tested | Aggregation | Allowed |
| Flexibility register | No flexibility register | Network representation | Market area based on network information |
| Baselining method(s) | Not trialed (yet) | Clearing mechanism | Continuous market |

## Euroflex

| General Information | | | |
|---|---|---|---|
| **Country** | Norway | **Flex buyer** | DSOs and TSO |
| **Status initiative** | Live market (in operation since 2019 through prior NorFlex project) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (NODES) | **Flex services** | Congestion management and balancing |
| **Market operator** | Independent MO | **Grid topology** | Both radial and meshed |
| **Market model** | Sequential market | **Grid level** | 22kV-66 kV |

| Product characteristics | ShortFlex | LongFlex | MaxUsage |
|---|---|---|---|
| **Product type** | Active power | Active power | Active power |
| **Capacity procurement** | No | Yes, unlimited time ahead | Yes, unlimited time ahead |
| **Energy procurement** | Yes, week to hour ahead | Yes, through ShortFlex | No |
| **Duration of capacity reservation** | NA | In practice seasonal, but no limit specified in the | In practice seasonal, but no limit specified in the |
| **Duration of energy delivery** | Min. 1 hour | Min. 1 hour | Min. 1 hour |
| **Activation** | When bids are matched | Through ShortFlex | At moment of capacity procurement |
| **Capacity remuneration** | No | Yes, pay-as-bid | Yes, pay-as-bid |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid (if activated) | No |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Statistical methods, Meter before/meter after, FSP's own method (to be approved by DSO) | **Clearing mechanism** | Tender for LongFlex and MaxUsage<br>Continuous market for ShortFlex |

## PORTUGAL

In **Portugal** there is just one LFM, operated by E-REDES, the main Portuguese DSO. The LFM is called FIRMe, and it originally identified eight geographical areas across mainland Portugal with specific network constraints. The project is approved by the Energy Services Regulatory Authority and is followed up actively to use the outcomes to inform future regulatory developments. FIRMe project is running since 2023 to test LFMs in Portugal. The project has two main goals: 1) Develop internal capabilities related with procurement and management of flexibility services. This includes incorporating flexibility alternatives in grid planning assessment methodologies, testing flexibility procurement frameworks, operating the grid using flexibility contracts, and test settlement and billing processes. 2) Test market liquidity and simultaneously raise FSPs awareness, encouraging them to participate in LFMs.

In this market, operated by E-REDES with the help of PICLO's platform for services procurement, 3 different congestion management products were tendered. They were based on the standardised UK products with a LT character. In all products, there is capacity procurement, representing a formal commitment to deliver the service, if the service is needed. In the Dynamic product, there is an additional notification by the DSO, 1 week ahead in case there is an actual capacity need, and this is then linked to a formal commitment by the FSP. This also implies that for the Dynamic product, there is only capacity remuneration for the weeks that the FSP has confirmed their availability after the notification. The procurement process is a LT tender process. It should be noted that FIRMe is a regulatory pilot project approved by the NRA with a 2-year duration. Therefore, the flexibility contracts signed between E-REDES and the FSPs are also valid for 2 years. The flexibility services can be provided in multiple service windows that can cover the total period of the contracts or just some periods and are divided into seasons/ days and periods within a day, following E-REDES LT flexibility vision. In the near future, it is expected that a new set of flexibility opportunities will be tendered as part as a new regulatory pilot project.

## FIRMe

E-REDES

| General Information | | | |
|---|---|---|---|
| Country | Portugal | Flex buyer | DSO only |
| Status initiative | Pilot (in operation since 2023) | Involved assets | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market platform | Existing (Piclo) | Flex services | Congestion management |
| Market operator | Independent MO | Grid topology | Both radial and meshed, but mainly meshed |
| Market model | Separate DSO LFM | Grid level | 10-60 kV |

| Product characteristics | Restore | Dynamic | Secure |
|---|---|---|---|
| Product type | Active power | Active power | Active power |
| Capacity procurement | Yes, years ahead | Yes, years ahead | Yes, years ahead |
| Energy procurement | No | No | No |
| Duration of capacity reservation | Service windows throughout the whole year | Service windows are tender defined | Service windows are tender defined |
| Duration of energy delivery | Min. 2 hours | Min. 2 hours | Min. 2 hours |
| Activation | 15 minutes ahead | 15 minutes ahead | 15 minutes ahead |
| Capacity remuneration | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid |
| Energy remuneration | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Ex-ante and ex-post | Aggregation | Allowed |
| Flexibility register | Flexibility register on the level of LFM | Network representation | Market area based on network information |
| Baselining method(s) | Statistical methods | Clearing mechanism | Tender |

**SLOVENIA**

**Slovenia** counts 5 DSOs, the biggest one being Elektro-Ljubljana which operates about one-third of the country (central and south-eastern part of Slovenia). Another Slovenian DSO is Elektro Primorska. **Elektro Ljubljana** currently has an operational live market for the procurement of flexibility, specifically to solve overloaded MV/LV transformers. As such, the majority of their flexibility providers are households. They currently work with one congestion management product; however, they are also working on a voltage control product. Elektro Ljubljana has developed its own flexibility platform in-house. The map shows the geographical spread of their LFM.

**Elektro Primorska** is in the process of setting up an LFM. The Slovenian pilot site encompasses an industrial park in the town of Ajdovščina, located in the south-western part of Slovenia. It comprises approximately 340 industrial and commercial buildings connected to the power network managed by the DSO Elektro Primorska. The pilot is part of the **HEU STREAM project** in which multiple tools are developed, among others the sGRID tool which increases DSO grid observability, allowing for better insights into when and where flexibility is needed. This tool supports the sMART tool which is a central platform for flexibility trading activities. As illustrated below, the market consists of both ST and LT active power products, where the LT product implies an obligation to bid in ST flexibility products. The market is still in preparation.

Slovenian grids are typically characterised by more intensively used LV networks, with long feeders. The LV part of the grid is much larger than the MV part, resulting in more loads being connected.

# Fleksibilnost Elektro Ljubljana

Elektro Ljubljana

## General Information

| | | | |
|---|---|---|---|
| **Country** | Slovenia | **Flex buyer** | DSO only |
| **Status initiative** | Live market (in operation since 2023) | **Involved assets** | Residential and commercial assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Own developed | **Flex services** | Congestion management |
| **Market operator** | DSO | **Grid topology** | Radial |
| **Market model** | Separate DSO LFM | **Grid level** | 0,4 kV |

| Product characteristics | Flexibility "PROŽNOST" |
|---|---|
| **Product type** | Active power |
| **Capacity procurement** | No |
| **Energy procurement** | Yes, seasonal |
| **Duration of capacity reservation** | NA |
| **Duration of energy delivery** | Max. 2 hours |
| **Activation** | ID (15 minutes ahead) |
| **Capacity remuneration** | No |
| **Energy remuneration** | Yes, pay-as-bid |

## Market characteristics and supportive processes

| | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Alternative approach | **Clearing mechanism** | Tender |

## Elektro Primorska STREAM pilot

| General Information | | | |
|---|---|---|---|
| **Country** | Slovenia | **Flex buyer** | DSO only |
| **Status initiative** | Pilot (in preparation, market test date TBD) | **Involved assets** | Industrial assets and residential PV generation |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Own developed (sMART) | **Flex services** | Congestion management |
| **Market operator** | DSO | **Grid topology** | Radial and meshed |
| **Market model** | Separate DSO LFM | **Grid level** | 0,4 - 20 kV |

| Product characteristics | Short-term flexibility product | Long-term flexibility product |
|---|---|---|
| **Product type** | Active power | Active power |
| **Capacity procurement** | No | Yes, weeks/months ahead |
| **Energy procurement** | Yes, ID (2,5 minutes before delivery) | No |
| **Duration of capacity reservation** | NA | Throughout the full week/month |
| **Duration of energy delivery** | 15 minutes | Min. 15 minutes |
| **Activation** | RT | RT |
| **Capacity remuneration** | No | Yes, pay-as-cleared |
| **Energy remuneration** | Yes, pay-as-cleared | Yes, pay-as-cleared |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Not allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Meter before/meter after | **Clearing mechanism** | Closed gate auction |

**SPAIN**

**Spain** has over 300 DSOs. Nevertheless, while there are numerous European-funded initiatives (such as **H2020 OneNet, H2020 Fever, HEU BeFlexible, and HEU FLOW**) exploring demand response and LFMs, there are currently no official live LFMs due to a lack of regulation.

To facilitate regulatory innovation in the energy sector, the Spanish Government launched a call for **Energy Regulatory Sandbox initiative** [134]. Because of that, almost all Spanish DSOs have launched a consortium to test Flexibility Services (Flexibility solutions for electricity distribution networks – the S2F pilot project), which includes different pilot projects cross a heterogeneous grid landscape, covering high-voltage (HV), medium-voltage (MV), and low-voltage (LV) networks. The sandbox will, among other things, test a single common national LFM platform, with OMIE (Spain's Nominated Electricity Market Operator) as the MO. It will also test the potential national implementation of the future NC DR.

This approach is designed to leverage efficiencies and simplify processes. As a result, there is strong collaboration among DSOs, with OMIE actively engaging with them to ensure that their requirements are incorporated into the LFM platform and that all market processes are aligned. The insights gained from the Regulatory Sandbox will be used to develop new regulations or update existing regulation, where necessary. It should be noted that the different European projects and pilot provided inputs in this sandbox through previous initiatives. For instance, the H2020 FEVER project, enable the exploration of alternative LFM designs through a custom-developed platform.

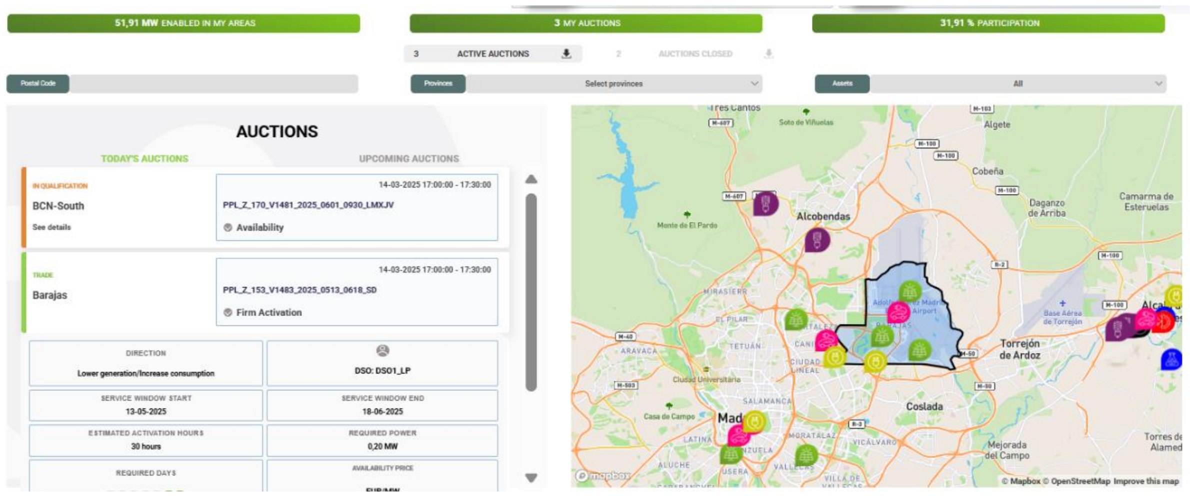


*Figure: OMIE LT flexibility local platform*

The products to be used in this Regulatory Sandbox, S2F, are the result of experience gained through the Spanish H2020 OneNet demonstrator and will be further validated in the Spanish HEU BeFlexible and FLOW demonstrator. Product procurement consists of both LT local services and ST local services:

- In the LT auction, the DSO can procure flexibility services (capacity and energy) from years to days ahead of delivery.
- In the ST market, the DSO can procure flexibility services (energy) for the day ahead or intraday.

The picture above gives a visualization of the OMIE long term local platform.

The Regulatory Sandbox S2F, submitted to the Energy Regulatory Sandbox call received a positive preliminary evaluation from the Ministry of Energy in March of 2025 and currently awaiting final approval.

The product- and market design described in the ID-card reflects the current set-up for all LFMs currently under consideration in the Regulatory Sandbox S2F. However, it is to be noted that not all decisions are final yet, and some characteristics might still change or have to be decided.

Finally, **Aněll**, alongside Cuerva Energía, also played a pioneering role in the development of the Spanish regulatory sandbox approved by the Ministry. Through their pilot, they gained insights into market operations and contributed to shaping the initial proposals for the regulatory sandbox in Spain. The main objective of the initiative was to test and propose a harmonised framework for local LFM regulation. This LFM was part of the **H2020 FEVER project** and served as a preparatory step toward future legislation on flexibility markets in Spain. Unlike other Spanish initiatives covered in this study, the FEVER project enabled the exploration of alternative market designs and tested the coexistence of competitive platforms using a custom-developed market platform.

# Spanish Regulatory Sandbox

| General Information | | | |
|---|---|---|---|
| **Country** | Spain | **Flex buyer** | DSO only |
| **Status initiative** | Pilots (in preparation, awaiting formal approval) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (OMIE market platform) | **Flex services** | Congestion management |
| **Market operator** | Independent MO | **Grid topology** | Both radial and meshed |
| **Market model** | Sequential market | **Grid level** | Depends on the pilot (LV, MV, HV possible) |

| Product characteristics | Long Term Local services | Short Term Local services |
|---|---|---|
| **Product type** | Active power | Active power |
| **Capacity procurement** | Yes, year ahead | No |
| **Energy procurement** | No | Yes, ID |
| **Duration of capacity reservation** | Timing window specified by DSO | NA |
| **Duration of energy delivery** | 60 minutes | 60 minutes |
| **Activation** | TBD by DSO | ID or DA |
| **Capacity remuneration** | Yes, pay-as-bid | No |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Common flexibility register with other markets | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Not specified (yet) | **Clearing mechanism** | Closed gate auction |

## Local Flexibility Market in Anĕll's grid

| General Information | | | |
|---|---|---|---|
| **Country** | Spain | **Flex buyer** | DSO only |
| **Status initiative** | Pilot (inactive in 2024) | **Involved assets** | Commercial and industrial assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Own developed (FEVER platform) | **Flex services** | Congestion management |
| **Market operator** | Independent MO | **Grid topology** | Radial |
| **Market model** | Separate DSO LFM | **Grid level** | 400 V |

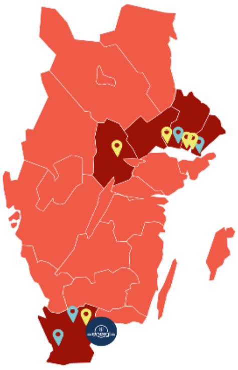
| Product characteristics | Congestion management with upward flexibility |
|---|---|
| **Product type** | Active power |
| **Capacity procurement** | Yes, planned before the start of the pilot |
| **Energy procurement** | No |
| **Duration of capacity reservation** | For the full duration of the pilot |
| **Duration of energy delivery** | 1 hour |
| **Activation** | DA |
| **Capacity remuneration** | Pay-as-bid agreed upon |
| **Energy remuneration** | Pay-as-bid agreed upon |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Not specified in the pilot | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Simplified network model |
| **Baselining method(s)** | Statistical methods | **Clearing mechanism** | Closed gate auction |

## SWEDEN

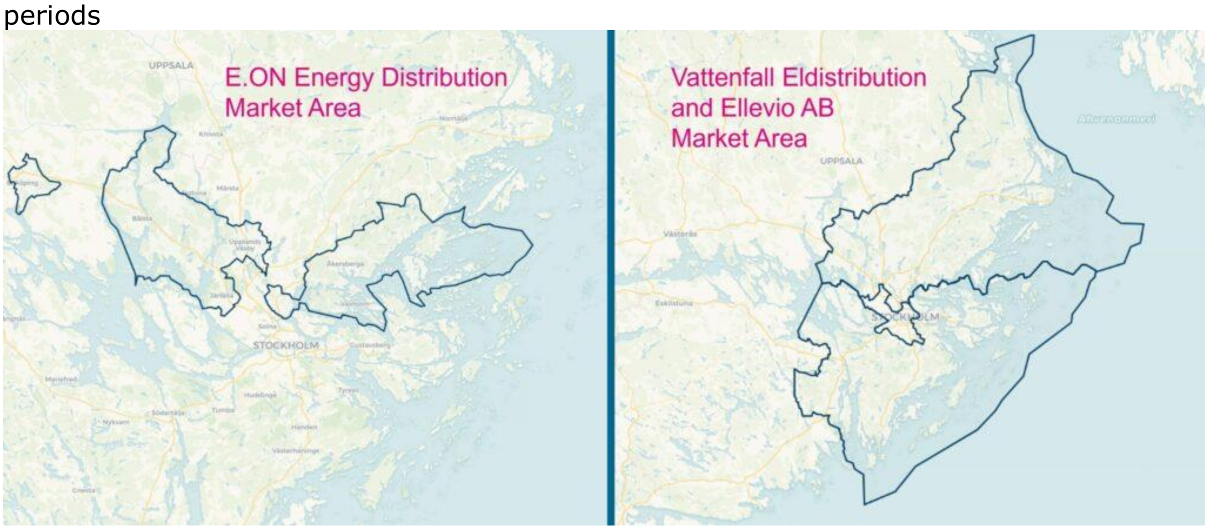
With about 150 DSOs, **Sweden** has multiple LFMs. Among others there is the SthlmFlex initiative between the TSO and some DSOs to test a regional flexibility market in the Greater Stockholm area. Another significant market is the Effekthandel Väst operated by Goteborgenergi. Although this initiative has a geographically small area, they have succeeded in bringing on a lot of FSPs. Moreover, historically Vattenfall Eldistribution, Ellevio and Jämtkraft have had LFM initiatives running, but in 2025 they have not re-opened their markets. They are still active, together with many other DSOs that have plans to start up initiatives. Furthermore, E.ON Energy Networks Sweden also operates 9

LFMs in Sweden. E.ON Energy Networks Sweden has developed its own in-house market platform SWITCH. However, since 2025, this platform is also used by a local DSO that started up a market within the E.ON Sweden regional market, C4 energi. This study covers the E.ON Energy Networks LFMs, SthlmFlex, and Effekthandel Väst and discusses them in more detail below. Generally, in Sweden, there are also many active collaborations and knowledge exchanges, among others leading to work in the direction of more standardised national local flexibility products.

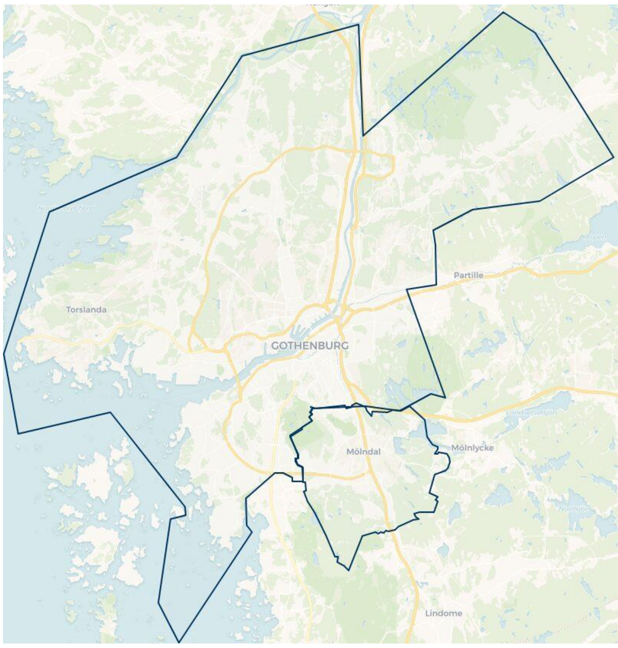


**E.ON Sweden** has kicked off its first LFM in 2019 as part of the Coordinet H2020 research project. Since then, they have increased their number of LFM, spread out mostly in the South of Sweden. All markets are using the in-house developed SWITCH platform, which consists of (1) a model to do forecasts and provide bid recommendations at the DSO side, (2) a market platform and (3) an FSP interface. The combination of these tools in one platform is unique compared to other market platforms. Moreover, SWITCH uses externally generated load forecasts as part of the flexibility need assessment. The E.ON markets have 3 different types of products with different time windows as explained in this ID-card.

**Sthlmflex** was a live market initiated to address the growing electricity capacity challenges in the Greater Stockholm area of Sweden. Launched in 2020 and finalised in 2024, the project is a collaborative effort involving the national TSO Svenska kraftnät, and regional DSOs Ellevio and Vattenfall. The primary objective of sthlmflex was to create and test a regional flexibility market that enhances coordination between the TSO and DSOs, as well as among the DSOs themselves, to ensure a reliable and efficient electricity supply in the region. The main purpose was to study how local flexibility could be used in case of grid constraints, in particular on the transmission grid, restricting capacity in connection points to the distribution grid when consumption was high (in particular during peak demand periods in winter months). The sthlmflex market operates seasonally, with trading periods




typically spanning from December to March. During these periods, DSOs purchase flexibility through the NODES platform, involving three types of products as discussed below. Through four winter seasons, the DSOs procured and activated local flexibility through the NODES platform. Existing bilateral contracts were included and administered in the platform, competing for activation with new contracts. Temporary contracts for increased capacity to the transmission grid were included as well and competed on price with activation of flexibility. Finally, for a limited period of time, bids from qualified FSPs were forwarded to Svk's mFRR market on a voluntary basis.




**Effekthandel Väst** is an LFM operating in the Gothenburg and Mölndal regions of Sweden (as can be seen on the map on the left). Established in January 2022 by Göteborg Energi Nät AB in collaboration with the independent market operator NODES, the platform aims to enhance the efficiency of the local electricity grid by trading power capacity. In the 2022/2023 season, Mölndal Energi Nät AB joined as a participant, further expanding the market's reach. The primary goal of Effekthandel Väst is to alleviate capacity constraints in the local electricity network during peak demand periods, such as the cold winter months. The market facilitates transactions where grid-connected business customers, or aggregators, can sell their flexibility by temporarily reducing electricity consumption or increasing production. This process helps mitigate load on the grid, ensuring a more stable and reliable electricity supply. Around 30 FSPs were actively selling flexibility using ca 640 assets as of the most recent trading season (winter 24-25). As discussed in this ID-card, there are three ways to sell flexibility in this market.

## E.ON Energy Networks Sweden

| General Information | | | |
|---|---|---|---|
| **Country** | Sweden | **Flex buyer** | DSO only |
| **Status initiative** | Live market (in operation since 2019) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Own developed (SWITCH) | **Flex services** | Congestion management |
| **Market operator** | DSO | **Grid topology** | Radial and meshed |
| **Market model** | Sequential market | **Grid level** | 10 kV-130 kV |

| Product characteristics | Local Flexibility Market Direct (LFM-d) | Local Flexibility Market Hourly availability (LFM-a) | Local Flexibility Market periodic availability (LFM-p) |
|---|---|---|---|
| **Product type** | Active power | Active power | Active power |
| **Capacity procurement** | No | Yes, week ahead to days ahead | Yes, before the start of the season |
| **Energy procurement** | Yes, DA / ID | No | No |
| **Duration of capacity reservation** | NA | Hours specified in the published need | Specific hours on week days in the winter season |
| **Duration of energy delivery** | 60 minutes | 60 minutes | 60 minutes |
| **Activation** | DA / ID | DA | DA/ID |
| **Capacity remuneration** | No | Yes, fixed price determined by DSO | Yes, fixed price determined by DSO |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante** | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Impact factors |
| **Baselining method(s)** | Nomination baselines | **Clearing mechanism** | Closed gate auction |

## Sthlmflex

| General Information | | | |
|---|---|---|---|
| **Country** | Sweden | **Flex buyer** | DSOs and TSO |
| **Status initiative** | Live market (inactive 2020-2024) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (NODES) | **Flex services** | Congestion management, balancing (mFRR) |
| **Market operator** | Independent MO | **Grid topology** | Meshed |
| **Market model** | Sequential market | **Grid level** | <= 220kV |

| Product characteristics | ShortFlex | LongFlex | ShortFlex Availability |
|---|---|---|---|
| **Product type** | Active power | Active power | Active power |
| **Capacity procurement** | No | Yes, timing TBD | Yes, several days ahead |
| **Energy procurement** | Yes, days-ahead to ID | Yes, through ShortFlex | Yes, through ShortFlex |
| **Duration of capacity reservation** | NA | Few weeks to a season, during certain or all hours of the contract period | 1 hour |
| **Duration of energy delivery** | 1 hour blocks | 1 hour blocks | 1 hour blocks |
| **Activation** | When bids are matched; additional dispatch | Through ShortFlex | Through ShortFlex |
| **Capacity remuneration** | No | Yes, pay-as-bid | Yes, price fixed for each tender |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Statistical methods, Nomination baseline, FSP's own method (to be approved by DSO) | **Clearing mechanism** | Continuous market for ShortFlex. Tender for LongFlex / ShortFlex Availability. |

## Effekthandel Väst

| General Information | | | |
|---|---|---|---|
| **Country** | Sweden | **Flex buyer** | Multiple DSOs |
| **Status initiative** | Live market (in operation since 2022) | **Involved assets** | All connected assets, but mostly urban assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (NODES) | **Flex services** | Congestion management |
| **Market operator** | Independent MO | **Grid topology** | Radial |
| **Market model** | Separate DSO LFM | **Grid level** | <40 kV |

| Product characteristics | ShortFlex | LongFlex* | MaxUsage** |
|---|---|---|---|
| **Product type** | Active power | Active power | Active power |
| **Capacity procurement** | No | Yes, timing TBD | Yes, timing TBD |
| **Energy procurement** | Yes, days-ahead to ID | Yes, through ShortFlex | No |
| **Duration of capacity reservation** | NA | Few weeks to a season (ca 3 months) | Few weeks to a season (ca 3 months) |
| **Duration of energy delivery** | 1 hour blocks | 4 hour blocks | 3-4 hour blocks |
| **Activation** | When bids are matched | Through ShortFlex | At moment of capacity procurement |
| **Capacity remuneration** | No | Yes, pay-as-bid | No |
| **Energy remuneration** | Yes, pay-as-bid | No | Yes, pay-as-bid |

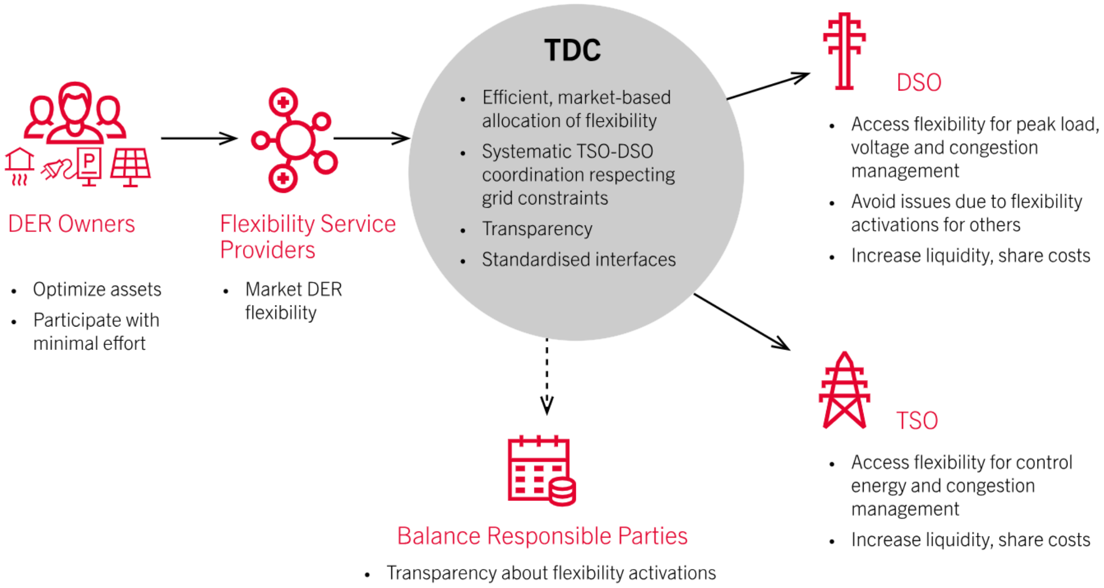
| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register on the level of LFM | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Statistical methods, Meter before/meter after, Nomination baselines, FSP's own method (to be approved by DSO) | **Clearing mechanism** | Continuous market |

**SWITZERLAND**

In **Switzerland**, unbundling is not yet complete, implying that the DSO also takes up, among other, energy and supply activities for small customers with less than 100MWh yearly consumption. Furthermore, for historical reasons, Swiss DSOs each have the option to control flexibility (through ripple control system, direct control, LFM solutions…). Given the fact that there are over 600 DSOs in Switzerland, a mix of solutions is applied as each DSO individually decides which solution to go for. To illustrate this, one of the initiatives presented in this study is the LFM that Azienda Elettrica di Massagno (AEM) SA, a small Swiss DSO, is setting up. In addition, the study also captures inputs from the Parity project which also has a finalised Swiss pilot. In contrast, this study also covers a TDC project at the national level in which the TSO (Swissgrid) with 8 DSOs has successfully completed the development of a new common market concept for providing grid services. This market, which involves coordination between the TSO and different DSOs, will be thoroughly tested in the next project phase. The ID-cards below discuss these three initiatives.


The LFM created in the context and funded by the Horizon Europe **OPENTUNITY** project focuses on a small district within the municipality of Massagno in Ticino canton, south of Switzerland. Adapted and extended at the beginning of the project to include all buildings connected to the same MV/LV transformer, the LFM investigates the impact of aggregating small public and private flexibilities (e.g., heat pumps, EV chargers) for providing services to the local DSO. The extended market area comprises residential buildings, mainly condominiums, and commercial activities. The LFM aims to prove the concept of peak shaving at the trafo station, targeting daily morning and evening demand peaks. As the local DSO and electricity provider in the area, AEM is interested in assessing the potential technical and economic benefits of the LFM and based on pilot validation results, potentially scaling up the solution to the wider grid. The market design and products described in this ID-card are still under development since the pilot is currently in preparation. As discussed below, the pilot foresees two products, each targeting different technologies: one for both upward and downward flexibility (e.g., batteries) and one for only downward flexibility (e.g., EVs).

The **Swiss TSO-DSO-Coordination (TDC) initiative**, is an initiative preparing a common TSO-DSO flexibility market. The project consists of different phases, starting with phase A, phase B and now moving into phase C. Phase A was a pilot project involving Swissgrid, ewz (DSO of the city of Zurich), and Equigy, where they tested a simple rule-based coordination concept. This included a traffic light system for the DSO and data exchange via Equigy's platform. While the pilot demonstrated that communication worked effectively, they found that the coordination concept itself was not scalable due to the short timeframes and the large number of DSOs in Switzerland.




As a result, the collaboration was extended to more DSOs and FSPs and moved into Phase B, where the focus shifted to refining the concept. This phase involved reviewing different coordination models from literature and European studies to assess their suitability for Switzerland. The outcome of Phase B is the concept described in this ID-card. Now, as they enter Phase C, they are building upon these learnings to develop a more robust and scalable approach to coordination. They propose two products: a power in-/decrease product inspired by the mFRR product, and a power limitation product for more local sources. The picture gives an overview of the TDC concept at a glance. It should be noted that in the ID-cards, the exact GCT or the energy procurement are still to be defined. They will be close to actual delivery, but x minutes before the GCT of the mFRR market.

During the H2020 **PARITY** project, a blockchain based market platform was developed in-house with the goal to achieve a high level of automation in the operation of the market. The platform was developed and tested in a pilot site managed by AEM SA in response to increasing congestion levels due to rising penetration of EVs, PV and electrification in the LV grids. The platform is different from traditional LFM platforms in the sense that it has an integrated local energy and flexibility market platform: a so-called "implicit LFM". This means a peer-to-peer market has been proposed, in which the energy trading prices can be altered when needed through a grid signal, reflecting any forecasted grid congestions at the local transformer (through a traffic light approach). There are different possible states:

- green: normal operation of the LEM/LFM, it means that there are no constraint violations.

- yellow: prices are influenced by the DSO to solve forecasted congestion.

- red: P2P LEM/LFM is temporarily suspended due to grid congestion and flexibility requests are sent by the DSO. In this situation, DSO can override market-based contracts and perform direct load control.

As a consequence, this ID-card does not include the traditional product descriptions as these do not apply in this project. The market design consists of an implicit mechanism for steering a local P2P market through additional grid-related price signals. An automated market clearing mechanism is developed in the platform to manage all the interactions. The market platform uses smart contracts and virtual credits linked to real currency, ensuring secure and transparent transactions.

## Swiss Opentunity Demo

| General Information | | | |
|---|---|---|---|
| **Country** | Switzerland | **Flex buyer** | DSO only |
| **Status initiative** | Pilot (in preparation, planned start Q2 2025) | **Involved assets** | Residential and commercial assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (NODES) | **Flex services** | Congestion management |
| **Market operator** | Independent MO | **Grid topology** | Radial |
| **Market model** | Separate DSO LFM | **Grid level** | 400 V |

| Product characteristics | Power limitation product | Power inc/dec product |
|---|---|---|
| **Product type** | Active power | Active power |
| **Capacity procurement** | No | No |
| **Energy procurement** | Yes, days ahead to ID | Yes, days ahead to ID |
| **Duration of capacity reservation** | NA | NA |
| **Duration of energy delivery** | TBD | TBD |
| **Activation** | Direct activation by DSO (for testing purposes in the pilot) | Direct activation by DSO (for testing purposes in the pilot) |
| **Capacity remuneration** | No | No |
| **Energy remuneration** | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Not part of the project | **Aggregation** | Allowed |
| **Flexibility register** | No flexibility register | **Network representation** | Market area based on network information |
| **Baselining method(s)** | Not trialed (yet) | **Clearing mechanism** | Continuous market |

## TSO-DSO Coordination (TDC Switzerland)

swissgrid

| General Information | | | |
|---|---|---|---|
| **Country** | Switzerland | **Flex buyer** | DSOs and TSO |
| **Status initiative** | Pilot (in preparation, market opening date TBD) | **Involved assets** | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | TBD | **Flex services** | Congestion management and voltage control |
| **Market operator** | TBD | **Grid topology** | Meshed and radial |
| **Market model** | Common market | **Grid level** | All voltage levels |

| Product characteristics | Power in-/decrease | Power Limitation |
|---|---|---|
| **Product type** | Active power | Active power |
| **Capacity procurement** | Yes, timing TBD | Yes, timing TBD |
| **Energy procurement** | Yes, ID (25 min + x minutes) | Yes, ID (TBD) |
| **Duration of capacity reservation** | TBD | TBD |
| **Duration of energy delivery** | 15 minutes | 15 minutes |
| **Activation** | ID (7,5 min before delivery) | ID (TBD) |
| **Capacity remuneration** | Yes, TBD | TBD |
| **Energy remuneration** | Yes, TBD | TBD |

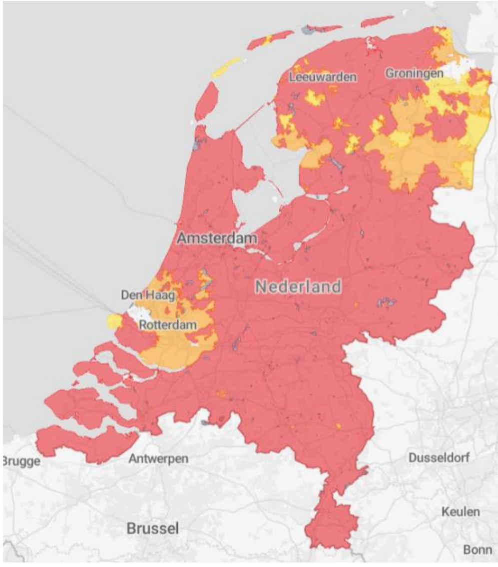
| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Flexibility register (TBD whether common or at LFM level) | **Network representation** | Impact factors |
| **Baselining method(s)** | Different methods under investigation | **Clearing mechanism** | Closed gate auction |

## PARITY Swiss pilot

| Flexibility need and location | |
|---|---|
| Country | Switzerland |
| Status initiative | Pilot (Finalized) |
| Flex services | Congestion management |
| Grid level | 230 V |
| Grid topology | Radial |

| General Information | |
|---|---|
| Flex buyer | Small consumers and FSPs |
| Market platform | Own developed (Parity platform) |
| Involved assets | Residential and commercial |
| Market model | P2P market |
| Baseline | Statistical methods |

**THE NETHERLANDS**




The Netherlands has 6 DSOs in total. The country is currently experiencing significant congestion issues. This is visualized on the figure on the right which shows a national capacity map for energy offtake, clarifying which regions suffer from longer waiting queues before new users can be connected.

As a result, the Netherlands is one of the most evolved countries when it comes to LFMs. It has an operational LFM in which the grid operators use the GOPACS platform to buy flexibility from consumers and flexibility service providers (CSPs) via the connected Power Exchanges. Procurement of local flexibility services takes place across the entire country from medium to extra-high voltage level.

The Netherlands is in the process of implementing varied policy measures to increase participation in the flexibility market and improve the data-sharing between the different market roles. Participation in the LFM for congestion services is often times via a Congestion Service Provider (CSP). The grid operators use Capacity Limiting Contracts in Day Ahead and the intraday Redispatch product to solve congestion problems. They also use Flexible Connection Agreements in order to optimise the grid usage. The Netherlands is continuously improving its market design and is currently developing market rules for aggregation.

# GOPACS

| General Information | | | |
|---|---|---|---|
| **Country** | The Netherlands | **Flex buyer** | DSOs and TSO |
| **Status initiative** | Live market (in operation since 2018) | **Involved assets** | Commercial, industrial, and any generation assets |

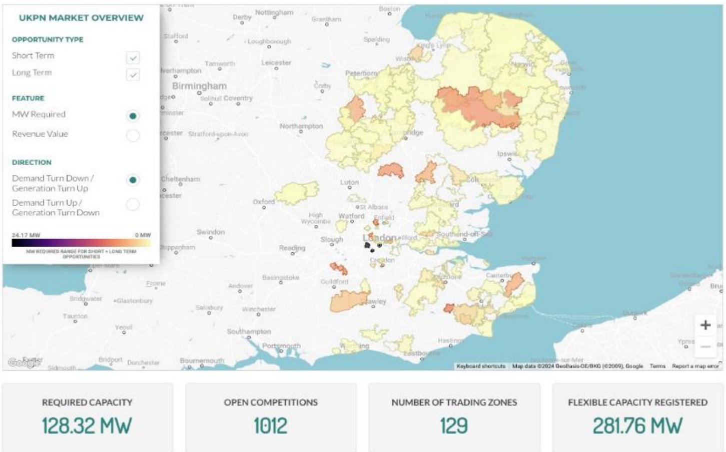
| Market governance | | Flexibility need and location | |
|---|---|---|---|
| **Market platform** | Existing (ETPA and EPEX SPOT) | **Flex services** | Congestion management |
| **Market operator** | independent MO | **Grid topology** | Both radial and meshed |
| **Market model** | Common market | **Grid level** | <400 V - 380kV |

| Product characteristics | Redispatch | Capacity Limiting Contract | Flexible Connection Agreement |
|---|---|---|---|
| **Product type** | Active power | Active power | Active power |
| **Capacity procurement** | No, unless combined with LT capacity availability | Yes, up to years ahead | No |
| **Energy procurement** | Yes, ID | No | No |
| **Duration of capacity reservation** | NA | Contractually defined time windows | NA |
| **Duration of energy delivery** | Min. 15 minutes | Min. 15 minutes | Depends |
| **Activation** | ID | DA | DA or LT |
| **Capacity remuneration** | No, unless specified in LT capacity availability | Yes, price according to contract | Yes, grid tariff reduction |
| **Energy remuneration** | Yes, pay-as-bid | Yes, price according to contract | No |

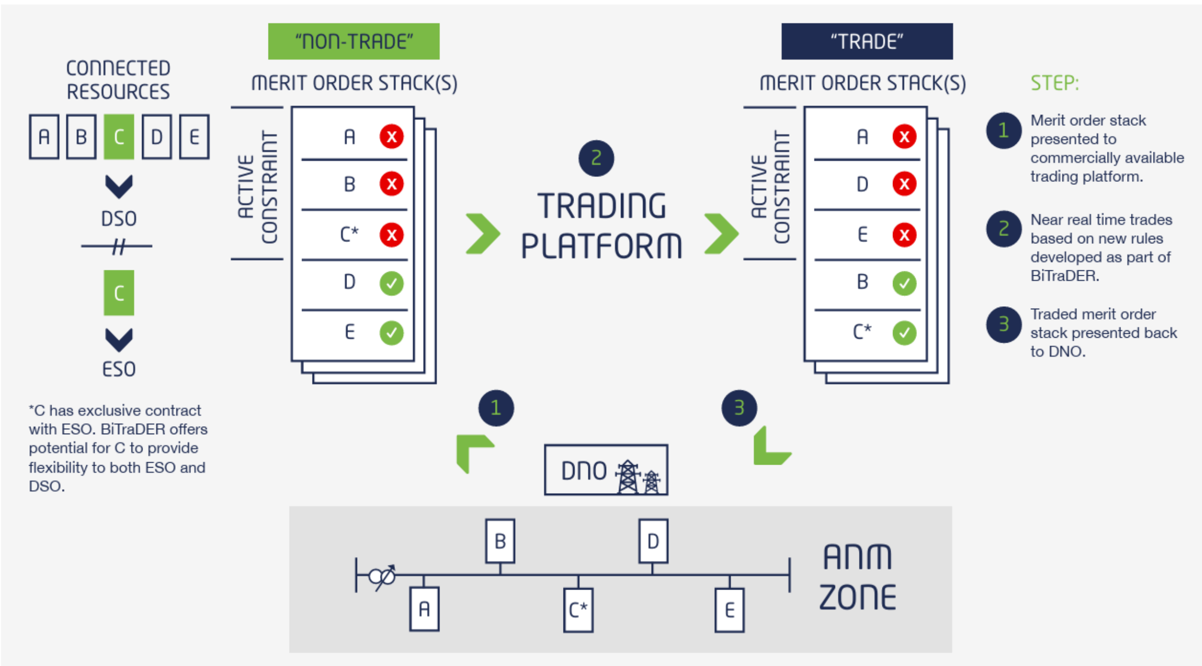
| Market characteristics and supportive processes | | | |
|---|---|---|---|
| **Product qualification** | Ex-ante | **Aggregation** | Allowed |
| **Flexibility register** | Common flexibility register with other markets | **Network representation** | Impact factors |
| **Baselining method(s)** | Nomination baselines | **Clearing mechanism** | Redispatch: continous market, other products: bilateral trade |

### UNITED KINGDOM

The **United Kingdom** is one of the most evolved countries when it comes to LFMs. There are 6 main DSOs in the country and most of them have already had their own LFM for several years to explicitly procure flexibility. The Energy Network Association, representing DSOs in UK and Ireland, set up an Open Networks Programme, with the goal to further open up LFMs to demand response, renewable energy and new low-carbon technologies by removing barriers to participation. The Open Networks programme has brought together the nine electricity grid operators in the UK and Ireland to work together to standardise customer experiences and align processes (products, PQ, etc.). This study covers the UKPN LFM, which is a more mature LFM, and the BiTraDer project, which is examining P2P trading through which customers with a FCA can sell their obligation to be curtailed.




The **UKPN** market comprises LT flexibility tenders combined with day-ahead flexibility procurement through an auction-based trading platform to secure flexibility and avoid further grid investments. Flexibility needs arise due to higher domestic electrification levels, concentrated urban areas on specific parts of the grids and higher RES connection demands. First market tenders started in 2018, but innovation projects kicked off in 2014. As presented in the ID-card below, three products are being procured. The visualisation above is a print screen of the UKPN market platform.




With regard to the **BiTraDER LFM**, it should be noted that in the UK, there are a mix of demand and generation customers that have a flexible connection agreement. These customers can be curtailed according to their position in the merit order stack, which determines the order in which they are to be curtailed in the event of a network constraint. BiTraDER is a pilot project which will investigate and trial new opportunities for these customers to trade their curtailment obligations with other customers who are on non-curtailable connection agreements, through a P2P trading platform. This enables flexible connections to avoid or reduce their risk of being curtailed. The pilot is still under preparation and some of the characteristics described in the ID-card might still be modified during the course of the project. BiTraDER falls under the governance of Ofgem's Network Innovation Competition 2021 and has seen the design and development of a new market to enable P2P trading of curtailment obligations.

## UKPN Local Flexibility Market

| General Information | | | |
|---|---|---|---|
| Country | UK | Flex buyer | DSO only |
| Status initiative | Live market (in operation) | Involved assets | All connected assets |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market platform | Existing (EPEX SPOT) | Flex services | Congestion management |
| Market operator | DSO (LT procurement), Independent MO (DA procurement) | Grid topology | Meshed |
| Market model | Separate DSO LFM | Grid level | 11 - 132 kV |

| Product characteristics | LT Scheduled Utilisation | Scheduled availability & operational utilisation | DA Scheduled Utilisation |
|---|---|---|---|
| Product type | Active power | Active power | Active power |
| Capacity procurement | No | Yes, ~6 months ahead | No |
| Energy procurement | Yes, ~6 months ahead | Yes, DA | Yes, DA |
| Duration of capacity reservation | Pre-contracted multiple-months window (for specific time window) | Pre-contracted multiple-months window (for specific time window) | NA |
| Duration of energy delivery | 30 minutes | 30 minutes | 30 minutes |
| Activation | LT delivery schedule | DA | DA |
| Capacity remuneration | No | Yes, pay-as-bid | No |
| Energy remuneration | Yes, pay-as-bid | Yes, pay-as-bid | Yes, pay-as-bid |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Ex-ante and ex-post | Aggregation | Allowed |
| Flexibility register | Flexibility register on the level of LFM | Network representation | Market area based on network information |
| Baselining method(s) | Statistical methods | Clearing mechanism | Closed gate auction |

## BiTraDER

electricity north west

| General Information | | | |
|---|---|---|---|
| Country | UK | Flex buyer | FSPs |
| Status initiative | Pilot (in preparation) | Involved assets | All assets above 6.6kV |

| Market governance | | Flexibility need and location | |
|---|---|---|---|
| Market platform | Existing (ElectronConnect) | Flex services | Congestion management |
| Market operator | Independent MO | Grid topology | Both meshed and radial |
| Market model | P2P market | Grid level | 6,6 kV - 132 kV |

| Product characteristics | BiTraDER Seller |
|---|---|
| Product type | Active power |
| Capacity procurement | Yes, DA |
| Energy procurement | No |
| Duration of capacity reservation | Specifically defined time window |
| Duration of energy delivery | Min. 30 minutes |
| Activation | ID (2 minutes) |
| Capacity remuneration | Yes, TBD |
| Energy remuneration | Yes, TBD |

| Market characteristics and supportive processes | | | |
|---|---|---|---|
| Product qualification | Ex-ante | Aggregation | Allowed |
| Flexibility register | Common flexibility register with other markets | Network representation | Market area based on network information |
| Baselining method(s) | Alternative approach | Clearing mechanism | Closed gate auction |

**No LFM**

From the following countries, although they currently do not yet have an LFM in place, we received the following information:

**Estonia** currently does not have an LFM. the Estonian DSO Elektrilevi indicated that, today, they do not have a clear financial win in procuring flexibility. However, in the long run, they are looking into ways to mitigate future issues until grid investments can be realised. A barrier in this regard is that it is hard to estimate the real costs and benefits of flexibility procurement. Nevertheless, they are preparing a pilot as a) gaining experience and knowledge on market-based flexibility procurement is important, b) regulation is moving towards the use of demand response and c) the volume of investments does not keep up with the needs of the network. They indicated that they have started a working group with Sadales Tikls (Latvian DSO) and ESO (Lithuanian DSO) discussing on flexibility methodology and use cases. Latvia has launched a project to develop its own flexibility market platform for congestion management and in the future also voltage control, with the intention of eventually deploying it across the Baltic region. However, the initiative is still in the conceptual development phase.

In **Romania**, we received feedback that there are currently no LFMs in the country. However, there is a discussion between the DSO and the TSO.

**Croatia** does not have any form of LFM in place today, but the DSO is setting up drafts of an LFM they aim to test in the future.

In **Luxembourg**, the primary SO, Creos Luxembourg S.A., which manages the majority of the country's electricity distribution network, is currently testing rule-based mechanisms for congestion management and voltage control in the low voltage grid in their Creos Living Lab.

In **Estonia**, the Estonian DSO Elektrilevi indicated that, today, they do not have a clear financial win in procuring flexibility. However, in the long run, they are looking into ways to mitigate future issues until grid investments can be realised. A barrier in this regard is that it is hard to estimate the real costs and benefits of flexibility procurement. Nevertheless, they are preparing a pilot as a) gaining experience and knowledge on market-based flexibility procurement is important, b) regulation is moving towards the use of demand response and c) the volume of investments does not keep up with the needs of the network.

Finally, in **Denmark**, today, no real market for procuring grid flexibility services exists. However, the TSO, Energinet, is using geo-tags in balancing markets as a means to utilise local flexibility to solve grid congestion issues. Furthermore, in November 2024, Denmark published a report [135], exploring how market-based flexibility can support a cost-effective, secure, and rapid green transition by optimally utilising existing grid capacity and potentially deferring costly grid investments. The report defines a timeline which sets out what needs to be achieved by when and specifies a number of recommendations on the market design.

# Annex 3: Overview of Platform Providers

In what follows, we provide an overview of the platform providers that gave inputs for this study. For each platform provider, a table is added with their key LFMs. Only when mentioned explicitly between brackets, some of these markets are closed or the result of past projects.

## Equigy

Founded in 2020 as a consortium of six TSOs (TenneT Netherlands, TenneT Germany, Transnet BW, Terna, APG and Swissgrid), Equigy distinguishes itself from the other platforms in this report by not functioning as a flexibility market platform. Instead of creating a market to offer specific flexibility services, Equigy acts as a "Common Front Door" by providing a standardised digital market interface to TSO-operated flexibility markets across different countries, primarily for balancing and redispatch services, allowing FSPs to participate more easily without having to adapt to multiple national systems. Equigy does not alter existing market structures or influences product definitions: Equigy acts as a technology layer that harmonises entry into these existing markets, ensuring a seamless interface without changing the fundamental market design or TSO system setup.

As a result, the role of Equigy is twofold. First, it facilitates easy market access by allowing market participants to interact with TSO balancing and redispatch markets through a standardised rest-API interface. Rather than developing separate IT integrations for each national market, FSPs can connect to Equigy once and use that connection to access multiple TSO markets, which minimises IT costs and investments, particularly (but not exclusively) for smaller aggregators and flexibility providers. Second, Equigy harmonises access across multiple markets by standardising technical communications between market participants and TSOs. It provides a single canonical data model that translates into the various national data formats and protocols used by different TSOs. While currently focused on TSO flexibility markets, Equigy's approach could be extended to DSO-led LFMs in the future; for now, its primary function remains the simplification and standardisation of access to TSO balancing and redispatch services.

| Current presence | Future presence |
| --- | --- |
| • Netherlands (TenneT) – Balancing services<br>• Austria (APG) – Balancing services<br>• Germany (Redispatch 3.0) – Redispatch Market-based pilot for Small Assets<br>• Italy (Terna) – TSO-DSO Coordination for PQ and balancing<br>• Switzerland (Swissgrid) – TSO-DSO Coordination pilot | • Netherlands (TenneT) – Balancing services<br>• Austria (APG) – Balancing services, redispatch<br>• Germany (Redispatch 3.0) – Balancing services, redispatch<br>• Italy (Terna) – Balancing services, redispatch<br>• Switzerland (Swissgrid) – Balancing services, redispatch |

## Electron

Electron is a UK-based technology company that has developed ElectronConnect, a configurable Flexibility Market Platform designed to enhance the trading and scaling of energy flexibility. Founded in 2015, Electron aims to optimise electricity grids for a Net Zero future by enabling SOs, network utilities, Distributed Energy resources (DERs), and flexible energy consumers to efficiently manage variable renewable power and network capacity based on time and location.

ElectronConnect serves as a comprehensive marketplace facilitating the coordinated exchange among market participants, including buyers and sellers. The platform encompasses all market-relevant processes such as registration, PQ, trading, and post-trading activities like validation and settlement. Its design emphasises minimal data and information exchange requirements, ensuring neutral and transparent market operations. To cater to diverse market needs, ElectronConnect offers pre-configured market templates for common market archetypes (such as community energy markets, ENA-standardised flexibility products in the UK, curtailment markets), allowing for quick initiation or scaling of flexibility markets. These templates enable buyers to request multiple flexibility products and services within a unified platform, while flexibility providers gain enhanced visibility over market locations and activities, reducing barriers to participation.

| **Current presence** |
| --- |
| UK<br>• Electricity North West (ENWL) - end-to-end Flexibility Market Platform deployment, and BiTraDER project (day ahead, many-to-many market to trade curtailment)<br>• Scottish and Southern Electricity Networks (SSEN) -Scaling flexibility procurement with Flexibility Market Platform deployment, and TraDER project (asset-to-asset curtailment avoidance)<br>• National Grid Electricity Distribution (NGED) Integrate with NGEDs Market Gateway to connect DERs to the grid and increase DER participation in flex.<br>• London Hydro - Project L2L - multi-market approach for visibility of DERs<br>US<br>• Silicon Valley Clean Energy - ResponDER project (market-based approach for leveraging local flexibility |

## NODES

NODES is a Norwegian technology company, founded in 2018, that provides a technology platform and an integrated market design to facilitate access to distributed flexibility for grid services across all grid levels. The NODES market platform enables a coordinated exchange and interaction among the defined market agents, i.e. buyers and sellers covering all market-relevant processes related to registration and PQ, trading and post-trading processes, i.e. validation and settlement. Moreover, the platform and developed technology solutions enable SOs to coordinate the use of flexibility, ensuring that activations do not impact the grid or the system balance negatively, and to communicate transparently their flexibility needs to FSPs. NODES market and platform for flexibility procurement is designed to run with minimum data and information exchange requirements to allow for a neutral and transparent operation of the flexibility procurement process.

NODES provides its platform and technology solutions as requested and according to the flexibility market integration into the energy landscape, optionally (1) to operate flexibility markets as an Independent Market Operator or (2) as SaaS to grid operators to facilitate the market operation for flexibility procurement.

Concerning market initiation and setup, all NODES markets are initiated upon the SO's request and offer a high level of configurability. Generally, NODES suggests three key products depending on the SOs' preference:

- **ShortFlex**: Activation Market where flexibility can be bought by the DSOs/TSOs to address an immediate need to cover unforeseen grid issues. FSPs can offer flexibility of their assets ensuring that the different technologies can compete on a level playing field.
- **LongFlex**: DSO/TSO can reserve flexibility via an availability payment to secure the option to have access to flexibility over a defined time period in the future to ensure system security and stability. According to the agreements in the LongFlex contract the seller of flexibility commits to always submit ShortFlex orders enabling the DSO or TSO to activate the reserved flexibility if needed.
- **MaxUsage**: FSPs offer the SO to limit the power drawn/injected to or below a certain power for specific times and assets in the grid. If the SO purchases this

service, the FSP will be remunerated for reducing the power to/below the promised limit (without activation signal).

| **Current presence** | | **Past presence** | |
|---|---|---|---|
| Norway | *Euroflex* | UK | *IntraFlex* |
| Sweden | *Effekthandel Väst,* | Norway | Smart Senja (about to close), Norflex (continued in the scope of Euroflex), Flex Lab |
| Canada | *Powershare, Hydro One* | Germany, Portugal, Poland | *H2020 EUniversal (ended project)* |
| Belgium | *Fluvius* | Sweden | *Sthlmflex, JämtFlex* |
| UK | *NPG project* | | |
| Finland | *FinFlex TSO-DSO congestion management market* | | |
| Greece, Switzerland, Spain | *HEU Opentunity* | | |

## N-SIDE

Since 2000, N-SIDE is a Belgian deeptech company that specialises in applying advanced analytics, operations research, and artificial intelligence to optimise complex decision-making processes across various industries, including energy. In the energy sector, N-SIDE offers a range of products and services designed to enhance energy market operations and flexibility procurement. N-SIDE provides robust market-clearing algorithms that optimise the matching of supply and demand in closed-gate auctions. These solutions are utilised by power exchanges and SOs to facilitate efficient energy trading. The algorithms consider various constraints, such as network congestion, to produce market clearing prices and volumes, thereby maximising social welfare.

With the Cornwall pilot, N-SIDE further evolved its offering towards a Local Market Platform which can be operated in different ways. The N-SIDE Market design services range from state-of-the-art market modelling, and algorithm development to quantitative simulations, and cover both LT and ST markets for capacity, energy, and balancing.

The N-SIDE product offering is modular by nature. N-SIDE can add blocks to the product on request of the SOs. N-SIDE provides auction-based electricity market clearing algorithms, currently applied in powering exchanges in and outside Europe.

| **Current presence** | | **Past presence** | |
|---|---|---|---|
| Europe | Development with EPEX SPOT regarding the LocalFlex market market-clearing algorithm | UK | Cornwall pilot |
| | | Portugal and Germany | H2020 EUniversal demos |
| | | Spain | H2020 Coordinet demo |
| | | Norway | Collaboration with Statnett and Tensio on T&D coordination |

### EPEX SPOT

The European Power Exchange EPEX SPOT operates ST physical electricity markets for the largest trading community in Europe. The gateway of EPEX SPOT market solutions includes Day-Ahead, Intraday and After-market power trading, Capacity and Guarantees of Origin auctions, Local Flexibility and Data services.

Since April 2024, EPEX SPOT operates an LFM platform on behalf of the largest British DSO UK Power Networks (UKPN), with over 200,000 flexible assets connected (as of July 2025). The EPEX SPOT Localflex trading system is auction based and allows both ST flexibility energy trading as well as LT flexibility capacity trading. In addition, EPEX SPOT is connected to the GOPACS initiative in the Netherlands and participates in the Horizon EU project Enflate in Switzerland, providing a dedicated platform for flexibility trading. Between 2017 and 2020, EPEX SPOT participated in the enera project in Germany, introducing a local component to energy trading. Enera demonstrated that a flexibility market is not only possible but also has real added value for the electricity value chain.

EPEX SPOT has progressively expanded its services to include LFMs, aiming to ease grid congestions, enhance grid stability and reducing costs of the green transition. Their Localflex platform is designed to efficiently centralise localised physical flexibility potentials where and when needed for local needs such as congestion management or voltage control, facilitating grid-oriented TSO-DSO coordination and ensuring optimisation of flexibility reservations and activations. EPEX SPOT products and market design are modular and can be adapted by SOs depending on their needs and requirements. EPEX SPOT ensures transparency and a neutral and independent market operation.

| **Current presence** | | **Past presence** | |
|---|---|---|---|
| UK | UKPN | DE | ENERA |
| NL | *GOPACS* | | |
| CH | *Horizon EU Enflate project* | | |

### OMIE

The Operador del Mercado Ibérico de Energía (OMIE), established in 1998, serves as the designated electricity market operator for the Iberian Peninsula, managing the day-ahead and intraday electricity markets in Spain and Portugal. In response to the increasing integration of distributed renewable energy sources into medium- and low-voltage networks, OMIE has been actively developing local LFMs in Spain. OMIE's vision is to serve as the sole market platform in Spain, enabling participation from all Spanish DSOs, which number over 300. This centralised approach mitigates potential barriers for aggregators or participants operating across different DSO areas, ensuring consistent market-based rules and conditions that uphold transparency, competitiveness, and non-discriminatory treatment for all participants and reporting to NRA

OMIE's approach involves the creation of a unified LFM platform. OMIE is in collaboration with DSOs and relevant associations, as well as aggregator, energy communities, energy storage and electric vehicle operators. This ensures that DSO and aggregators requirements are accurately captured and that their processes align seamlessly with the platform's operations. As the Spanish NEMO, OMIE facilitates the integration of LFMs with existing wholesale electricity processes across the Iberian Peninsula and unify connection requirements, warranties and the settlement process of all the markets under only one central party. This fact, simplify participation in all the electricity markets managed by OMIE.

The market model is currently in the design and piloting phase, drawing insights from European flexibility market cases. OMIE's LFM design features both LT and ST products:

- **LT Products**: These allow DSOs to reserve flexibility over extended periods, creating a commitment of availability between parties.
- **ST Products**: Integrated with DA and ID markets, these products enable participants to offer flexibility in near real-time, providing opportunities to adjust to updated forecasts and market conditions.

This structure ensures that long-term and ST LFMs are interconnected, allowing for renegotiation of activations in the ST market as needed. Aligning LFMs with the intraday market timeline contributes to avoid adverse impacts on grid processes.

| Current presence | | Past presence | |
|---|---|---|---|
| Spain | Regulatory Sandbox | Spain | IREMEL project |
| | | | SIMFLEX project |
| | | | V2Market |
| | | | Redream |

## GME

Gestore dei Mercati Energetici (GME) serves as Italy's national energy market operator, overseeing the organisation and management of electricity and natural gas markets. In response to the evolving energy landscape and the increasing need for grid flexibility, GME has expanded its services to include LFMs. GME's LFM Platform facilitates the procurement of flexibility services by DSOs by collecting the offers of the BSP, determining market results per each auction and performing settlement operations according to the metering data provided by each DSO. The architecture allows multiple DSOs to connect their technical systems to a unified market interface, streamlining the acquisition of flexibility services. This setup promotes a plug-and-play approach, enabling DSOs to swiftly integrate and commence flexibility procurement while acknowledging the diverse requirements of different DSOs, allowing for customisation of flexibility products based on specific local needs. While the communication protocols, the market procedures and the settlement processes are standardised to ensure interoperability, the products and services offered can vary, reflecting the unique demands of each DSO's network.

The platform is compatible with the technical processes of other DSOs. This centralised approach reduces operational/administrative complexities, providing a single interface for all DSOs and FSPs. There is a strategic vision to further integrate the market interface platform with GME's existing systems. This integration aims to enhance operational efficiency and provide a seamless experience for all stakeholders involved in Italy's LFMs.

| Current presence | | Past presence | |
|---|---|---|---|
| Italy | RomeFlex | | |
| | *MindFlex* | | |

## Piclo

Piclo, founded in 2013, is a London-based energy technology company which develops software solutions that enhance the flexibility and sustainability of electricity grids. In 2025, Piclo has evolved its flagship product, Piclo Flex, into Piclo Marketplace which serves as an independent marketplace connecting FSPs with Transmission and Distribution SOs to facilitate the procurement of local flexibility services. Through Piclo, SOs can access all FSP offers. This marketplace supports SOs in the end-to-end process of procuring and operating flexibility, while Piclo ensures the market is operated in a transparent and neutral way. The platform is composed of a series of functionality which SOs can subscribe to, based on flexibility needs and the required degree of process automation. As such, SOs can go through a menu of product and market characteristics, configuring the market according to their needs.

Over the years, Piclo has expanded its operations across multiple countries on three continents, including Europe (UK, Ireland, Italy, Portugal, Lithuania), Australia and the United States (New York State, Massachusetts, Connecticut, California), procuring flexibility services via auctions on its Piclo Marketplace. From the perspective of the FSPs, the Piclo Marketplace enables FSPs to view and access all global SO markets as well as other markets, including capacity market secondary trading. As of Nov 2025, there are over 450 market opportunities listed from over 650 SOs, utilities and even other FSPs who are seeking to buy flexibility. Specifically, Piclo has the ability to interface to multiple SO platforms. As such, an aggregator with multiple assets in different regions, can select during bid registration for which market they apply.

| **Current markets** | | **Past markets** | |
|---|---|---|---|
| UK | *UK Power Networks ; SP Energy Networks; Electricity North West; Northern Powergrid; Scottish and Southern Electricity Networks; National Grid Electricity Distribution; NESO* | | |
| Ireland | | ESB Networks | |
| Italy | E-Distribuzione | | |
| Lithuania | | ESO | |
| Portugal | E-REDES | | |
| Australia | CitiPower, Powercor, United Energy | | |
| US | in New York State, and Massachusetts (National Grid); Connecticut (United Illuminating, Eversource); California | | |

## GOPACS

GOPACS, founded in 2017 and operational since 2018, is a flexibility procurement and coordination platform that allows SOs (Dutch DSOs and TSOs) to acquire flexibility services from consumers, producers and FSPs. It uses multiple channels to procure this flexibility, among which Power exchanges (such as ETPA and EPEX SPOT) are an important source. GOPACS is therefore not a power exchange itself nor mere a market platform.

GOPACS is developed to a) ensure coordination between DSO-TSO and DSO-DSO, to be able to respect the local grid limitations of each grid operator and b) to allow both TSO and DSOs to use flexibility available in each other's grid. GOPACS supports the SOs with the PQ, selection & activation of flexibility and verification process. GOPACS is the driving force behind a uniform and accessible flexibility market in the Netherlands and provides a coordinated solution for all congestion problems.

GOPACS facilitates the regulatory products and contracts for congestion management; Redispatch product, Capacity Limiting Contracts and Flexible Connection Agreements. In the future (2026) GOPACS expects to also support a reactive power product.

| Current markets | | Past markets | |
|---|---|---|---|
| The Netherlands | GOPACS | | |

## Annex 4: Assessment framework

| Objective | Criterion | Indicators | Scoring scheme |
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| 1. Transparent markets | 1.1 Limited information asymmetry | Clear and transparent market clearing | Score 1: low traceability / high complexity<br>Score 2: some factors that influence traceability<br>Score 3: clear/transparent market clearing |
| | | Equal access to market-related information | Score 1: market-related information is not shared equally with all market participants<br>Score 2: market-related information is shared equally with existing market participants, but not with potential, new market participants.<br>Score 3: fully equal & transparent access to market-related information for all existing and new potential market participants. |
| | | Transparent verification and baselining | Score 1: no established verification process<br>Score 2: manual verification and/or no agreed on baseline method<br>Score 3: automatic verification / transparent baseline method |
| | | Transparent participation rules | Score 1: manual PQ / registration process or not yet developed<br>Score 2: automatic PQ process with easy registration<br>Score 3: score 2 + at least one additional measure:<br>- simplification of PQ process for small flex assets / assets of the same type<br>- common procedures / solutions with other markets or services |

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| | | Clear roles and responsibilities | Score 1: exact roles and responsibilities still to be defined<br>Score 2: indications of overlaps or gaps in roles and responsibilities, or concerns about the neutrality of certain roles, or concerns about whether specific responsibilities could lead to market distortions or biases<br>Score 3: clear unambiguous and agreed on roles and responsibilities + fully automated market clearing |
| | 1.2 Information sharing | Clear market rules communication | Score 1: No market rules communication<br>Score 2: Market rules defined, but limited availability<br>Score 3: Market rules publicly available and communicated well ahead of market opening |
| | | Sufficient flexibility needs communication | Score 1: No communication on flex needs<br>Score 2: Quite static need communication<br>Score 3: More dynamic need communication |
| | | Sufficient flexibility value communication | Score 1: No indication on value of flexibility<br>Score 2: Quite static flex value communication<br>Score 3: More dynamic flex value communication |
| | | Sufficient market-clearing results communication | Score 1: No market clearing results communication<br>Score 2: Aggregated market outcomes<br>Score 3: Non-aggregated market outcomes |
| 2. Non-discriminatory markets | 2.1 Technology-neutrality | Technology-neutral participation rules | Score 1: Only certain types of assets / grid users can participate<br>Score 2: All connected assets can participate, but there are certain minimum requirements / thresholds for participation which impact technology neutrality<br>Score 3: All connected assets can participate |

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| | | Technology-neutral product definitions | Score 1: Products are technology-specific, limiting participation to certain asset types.<br>Score 2: The nature of the product makes it difficult for some technologies to participate<br>Score 3: The combination of products in the LFM allows participation from all types of technologies, ensuring inclusiveness. |
| | 2.2 Minimised entry barriers | Simplified PQ processes | Score 1: PQ process not adapted<br>Score 2: Standard PQ process with limited complexity<br>Score 3: Standard PQ process with limited complexity with at least one measure for simplification, such as<br>- simplification of PQ process for small flex assets / assets of the same type<br>- common procedures / solutions with other markets or services |
| | | Allowed and inclusive aggregation | Score 1: Aggregation not allowed<br>Score 2: Aggregation allowed (at least spatial aggregation)<br>Score 3: Aggregation allowed and additional measure such as aggregated baseline, settlement at portfolio level, etc. |
| | 2.3 Fairness | Optimal and consistent market clearing | Score 1: Market clearing cannot ensure cost minimisation<br>Score 2: Market clearing aims for cost minimisation, but certain factors can lead to sub-optimality<br>Score 3: Market clearing ensures cost minimisation and consistency (less ad-hoc) |

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| | | Optimal and consistent pricing | Score 1: Sub-optimal pricing which can lead to overpayment for flexibility<br>Score 2: Sub-optimal due to limited granularity in pricing<br>Score 3: Optimal and consistent pricing/remuneration |
| | | Inclusive baseline options | Score 1: One traditional baseline approach originally proposed for non-LFM.<br>Score 2: Different traditional baseline approaches supported.<br>Score 3: Baseline approach(es) tailored to LFM needs or the flexible resources that can provide them. |
| | | Fair penalties | Score 1: There are no consequences for non-delivery, or the penalties are unreasonably high, potentially deterring participation.<br>Score 2: Reasonable penalty for non-delivery but the penalty does not give appropriate incentives to FSPs to participate or bid truthfully; The penalty mechanism may appear arbitrary or poorly aligned with performance.<br>Score 3: The penalty for non-delivery is reasonable, proportionate, and based on a well-thought-out formula that establishes a clear and transparent link between the level of non-delivery and the resulting penalty. |
| 3. Efficient markets | 3.1 Economic efficiency | Maximised social-economic welfare | Score 1: Clear indications of suboptimal clearing<br>Score 2: Automated market clearing which cannot ensure optimal market outcome<br>Score 3: Automated market clearing which ensures optimal market outcome |

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| | | Network constraints properly considered | Score 1: Market area based on network information<br>Score 2: Representation based on impact factors<br>Score 3: Advanced network models / Simplified network models |
| | | Automatic optimisation-based market clearing | Score 1: Manual selection by SO<br>Score 2: Automated with final check by SO<br>Score 3: Fully automated |
| | | Efficient market coordination | Score 1: Separate SO LFM<br>Score 2: Sequential market<br>Score 3: Common market |
| | | No unnecessary limitations through grid PQ | Score 1: Quite static grid PQ which can lead to too strict margins being applied<br>Score 2: More dynamic grid PQ which lowers the risk of keeping flex out of the market<br>Score 3: Very dynamic grid PQ updated for every market session / Integration grid constraints in market clearing of all impacted grids |
| | 3.2 High Liquidity | Availability of providers | Score 1: Low number of FSPs (less than 10)<br>Score 2: Medium number of FSPs (10-20)<br>Score 3: High number of FSPs (more than 20) |
| | | Offered flex vs. needed flex | Score 1: Offered flexibility < needed flexibility<br>Score 2: Offered flexibility similar to needed flexibility<br>Score 3: Offered flexibility > needed flexibility |
| | | Number of transactions | Score 1: Low number of transactions<br>Score 2: Medium number of transactions<br>Score 3: High number of transactions |
| | 3.3 Minimised risk of gaming | Min. opportunity for market power | Score 1: Low liquidity / number of FSPs<br>Score 2: Medium liquidity / number of FSPs<br>Score 3: High liquidity / number of FSPs |

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| | | Incentives for truthful bidding | Score 1: Low liquidity / number of FSPs<br>Score 2: Medium liquidity / number of FSPs<br>Score 3: High liquidity / number of FSPs |
| | | Prevention and detection of gaming | Score 1: No monitoring against / prevention of gaming<br>Score 2: Minimal monitoring against / prevention of gaming<br>Score 3: Mature monitoring against / prevention of gaming |
| 4. Integrated markets | 4.1 TSO-DSO coordination | TSO-DSO coordinated market | Score 1: Separate SO LFM<br>Score 2: Sequential DSO-TSO market<br>Score 3: Common market |
| | | Coordinated products design | Score 1: LFM Product(s) based on individual SO need<br>Score 2: LFM Product(s) based on / inspired by existing balancing product<br>Score 3: LFM Product(s) ~ balancing product |
| | | Coordinated PQ procedures | Score 1: PQ at the level of LFM<br>Score 2: Some level of coordination of PQ processes<br>Score 3: Common PQ for multiple DSO/TSO services |
| | | Coordinated baselining procedures | Score 1: Baseline methods defined at LFM level<br>Score 2: Baseline method defined at LFM level, but similar method as f.i. for balancing<br>Score 3: Same baseline method used as for other existing markets |
| | | Respecting all network limitations | Score 1: No consideration of impact on other grids<br>Score 2: Consideration of impacted grids as part of PQ |

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| | | | Score 3: Consideration of impacted grids during procurement or very dynamic grid PQ |
| | 4.2 DSO-DSO coordination | DSO-DSO alignment in flex provision | Score 1: No DSO-DSO coordination<br>Score 2: DSO-DSO aligned market design, processes or products<br>Score 3: DSO-DSO coordination during procurement |
| | 4.3 Alignment with existing markets | Market timing alignment with other flex markets | Score 1: No consideration of timings of balancing markets leading to overlapping timings<br>Score 2: Measures to allow bidding in both local / balancing markets<br>Score 3: Sequential market setting, joint procurement |
| | | Market timing alignment with DA/ID markets | Score 1: No consideration of timings of other wholesale markets leading to overlapping timings<br>Score 2: Measures to allow bidding in wholesale markets<br>Score 3: Sequential market setting, procurement local services via DA/ID wholesale market |
| | | Coordinated bid formats with other flex markets | Score 1: No coordinated bid formats<br>Score 2: Coordinated bid formats (aligned to the needed level to allow coordination)<br>Score 3: Harmonised bid formats (completely the same) |
| | | Coordinated bid formats with DA/ID markets | Score 1: No coordinated bid formats<br>Score 2: Coordinated bid formats (aligned to the needed level to allow coordination)<br>Score 3: Harmonised bid formats (completely the same) |

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| | 4.4 Optimal utilisation of resources across markets | Bid forwarding in place | Score 1: No bid forwarding possibility<br>Score 2: Manual bid forwarding by the FSPs possible<br>Score 3: Automatic bid forwarding |
| | | Co-optimised market clearing | Score 1: separate order book at the level of the LFM<br>Score 2: common order books with other markets with separate clearing<br>Score 3: common order books with other markets with joint clearing |
| 5. Secure network operation | 5.1 Operational security | Accounting for other SO's grid limitations | Score 1: No consideration of impact on other grids<br>Score 2: Consideration of impacted grids as part of PQ<br>Score 3: Consideration of impacted grids during procurement or very dynamic grid PQ (done for every market session) |
| | | Grid-checks for bid forwarding | Score 1: No grid checks in place for bid forwarding<br>Score 2: Static grid checks in place for bid forwarding<br>Score 3: Dynamic grid checks in place for bid forwarding |
| | | Effective verification and baselining | Score 1: A single traditional baseline approach, originally developed for non-LFM contexts.<br>Score 2: Multiple baseline approaches are available or baseline approach(es) tailored to LFM needs or the distribution connected assets is defined<br>Score 3: Multiple baseline approaches are available / baseline approach(es) tailored to LFM needs or the distribution connected assets is defined, with baseline monitoring and verification mechanisms in place. |

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| | 5. 2 Effectiveness in solving the SO need | Grid-impact inclusive market clearing | Score 1: Market area based on network information<br>Score 2: Representation based on impact factors<br>Score 3: Advanced network models / Simplified network models |
| | | Incentive mechanisms to deliver service | Score 1:Low incentive to provide the committed local service<br>Score 2: Some incentive to provide the committed local service<br>Score 3: High incentive to provide the committed local service |
| | | Reliable activation signal communication | Score 1: No (explicit) activation signal<br>Score 2: Manual activation signal<br>Score 3: Automatic activation signal |
| 6. Efficient network operation | 6.1 Optimal utilisation of flexibility mechanisms | Ability of flex to postpone investments | Score 1: Needed investment not known, no methodology in place<br>Score 2: LFM procurement based on trade-off with investment - but not sufficient flex available<br>Score 3: LFM procurement based on trade-off with investment - sufficient flex available |
| | | Maximised value-stacking potential | Score 1: Separate SO LFM<br>Score 2: Sequential market<br>Score 3: Common market |
| | 6.2 Synergy with other flexibility mechanisms | Coordinated use of explicit and implicit flex | Score 1: No coordination with potential negative impact on FSP / GU<br>Score 2: Impact of LFM considered on grid tariffs<br>Score 3: Coordinated use of implicit and explicit flex |
| | | Impact of other flex mechanisms considered | Score 1: Completely independent mechanisms<br>Score 2: GU with FCA can participate in the LFM |

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| | | | Score 3: Co-optimisation of LFM / FCA / other mechanism |
| 7. Consumer centricity | 7.1 Consumer engagement | Engagement mechanisms in place | Score 1: No engagement mechanism<br>Score 2: Consumer engagement only with existing FSPs<br>Score 3: Consumer engagement with all potential FSPs |
| | | Low complexity for participation | Score 1: No attention for or specific mentioning of this topic<br>Score 2: Overall low complexity for FSPs / flex assets to participate<br>Score 3: Overall low complexity for FSPs / flex assets to participate + additional supporting features and interfaces |
| | | Multiple participation options | Score 1: Separate SO LFM with no coordination efforts<br>Score 2: Separate SO LFM but with some coordination effort which allows value stacking<br>Score 3: Explicit measures to allow value stacking |
| | | Possibility of aggregation | Score 1: Aggregation not allowed<br>Score 2: Aggregation allowed (at least spatial aggregation)<br>Score 3: Aggregation allowed and additional measure such as aggregated baseline, settlement at portfolio level, etc. |
| | | Common flexibility register | Score 1: Flex register at the level of the LFM<br>Score 2: Common flex register with at least one other market<br>Score 3: Common flex register at MS level |

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| | 7. 2 Limited uncertainty | Clear participation rules and remuneration | Score 1: Participation rules are unclear, and expected remuneration is uncertain.<br>Score 2: Participation rules are clear, but BC estimation is not straightforward for FSPs.<br>Score 3: Participation rules are clear, and BC estimation by FSPs is feasible. |
| | | Clear visibility on flex needs | Score 1: No information sharing on expected future flexibility needs.<br>Score 2: Aggregated information on long-term flexibility needs and forecasts<br>Score 3: Specific and regularly updated information on flexibility needs, linked to specific locations. |
| 8. Stable market design | 8.1 Potential for harmonisation/standardisation | Standardised products | Score 1: LFM Product based on individual DSO need<br>Score 2: LFM Product shared with multiple DSOs (e.g. standardisation at MS level)<br>Score 3: Product based on existing market products (DA/ID/balancing) |
| | | Standardised baselining method | Score 1: Baseline method(s) defined at LFM level<br>Score 2: Baseline method defined at LFM level, but similar method as f.i. for existing markets or agreement on baseline methods between SOs<br>Score 3: Same baseline method used as for other markets |
| | | Standardised PQ process | Score 1: PQ at the level of LFM<br>Score 2: Some level of coordination of PQ processes<br>Score 3: Common PQ for multiple services |

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| | 8.2 Adaptable to changing market conditions | Harmonisation with ongoing market evolution | Score 1: No harmonisation efforts, market design based on local needs<br>Score 2: Efforts to have a future proof LFM market design to be able to scale up the market<br>Score 3: Efforts to integrate the LFM in an overall future proof market design |
| | 8.3 Replicability and Scalability | Min. implementation costs | Score 1: Low cost<br>Score 2: Medium cost<br>Score 3: High cost |
| | | Min. transaction costs | Score 1: Low cost<br>Score 2: Medium cost<br>Score 3: High cost |
| | | Min. market clearing complexity | Score 1: High complexity<br>Score 2: Medium complexity<br>Score 3: Min complexity |
| | 8.4 Interoperability | Enabled interconnectivity | Score 1: No interconnectivity; LFM operates as a standalone platform without data exchange or coordination.<br>Score 2: Partial interconnectivity; some data exchange exists, but not sufficient for coordinated operation or easy participation in multiple markets.<br>Score 3: Full interconnectivity; LFM is interoperable with other platforms, enabling real-time coordination and value stacking. |
| | | Standardised data formats | Score 1: Proprietary or undocumented data formats; no use of recognised standards.<br>Score 2: Some standardised formats are used, but not consistently or not aligned with EU best practices.<br>Score 3: Fully based on open, recognised standards; clear documentation and proven interoperability. |

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| | | Standardised interfaces / communication protocols | Score 1: No standard interfaces / communication protocols<br>Score 2: Standard interfaces / communication protocols developed at MS level or not well known or still under development<br>Score 3: Accepted standard interfaces / communication protocols at EU level |

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