APPUNTI DI ENERGIA

LOCAL FLEXIBILITY MARKETS: context, role and state of experimentation

February 2026

What is it about?

Local Flexibility Markets (LFMs) are innovative tools designed to help distribution networks manage the increasing complexity of the modern energy system more effectively. They allow network operators to **purchase "flexibility"**, defined as the ability of certain distributed resources — such as photovoltaic systems, domestic batteries, heat pumps, electric vehicles or modulating industrial loads — to temporarily alter their energy behaviour in order to solve local distribution network problems.
Although these interventions are small at the level of individual resources, they become a very useful tool for the electricity grid when aggregated: **they prevent overloads, stabilise voltage** and often make it possible **to avoid or postpone costly grid investments** (e.g. construction of new lines or replacement of existing lines or transformers).

Context: operational challenges and the deployment of DERs

The rapid evolution of electrical systems, driven by the decarbonization of the energy sector, sees electrical distribution networks among the protagonists, supporting the growth of electrification of consumption, the further spread of distributed generation (especially from renewable sources), and the increasing presence of storage systems (batteries). This change is contributing to the emergence of an increasingly decentralized electricity system, where energy comes not only from large power plants but also from thousands of small plants distributed throughout the territory.
However, the electrification of end uses and the spread of distributed generation pose certain critical issues that are well known to the Distribution System Operators (DSOs). One of the most frequent issues are **local congestions**, linked to simultaneous withdrawals or feed-ins into the same section of the network within a short period of time. Another problem concerns the **voltage**, which tends to increase in the middle of the day, when photovoltaic systems are at their peak production and the energy fed into the grid exceeds that consumed. In addition, in several primary substations, the phenomenon of **reverse flow** occurs, i.e., excess energy from low and medium voltage to the transmission grid. Added to this is a growing **lack of predictability**: production and consumption are increasingly variable and depend on multiple factors (e.g., user behavior based on weather conditions).
For many years, these problems were addressed directly by upgrading infrastructure: more robust and reliable cables were installed, more powerful transformers were added, and, when necessary, new lines were built. Although effective, this approach now shows its limitations, as it requires high investments, long implementation times, and is ill-suited to managing short-term critical issues or those concentrated in specific hours of the day. In this scenario, Distributed Energy Resources (DER) can support the management and resolution of such issues in distribution networks.
Distributed Energy Resources (DER) are energy resources connected to the distribution network (or sometimes operated behind the user's meter) **that can dynamically modulate energy inputs and withdrawals**. As shown in in Figure 1, DERs are now one of the key elements in the evolution towards more sustainable and efficient distribution networks, as they support the operation of the electricity system by providing flexibility services. These units are defined as "distributed" because they are not concentrated in a single point of the power system, but they are widespread and often small or medium-sized:

- **Distributed generation systems**, such as photovoltaic systems;
- **Storage systems**, such as domestic or industrial batteries;
- **Flexible loads**, which can temporarily increase or reduce their consumption (e.g., heat pumps, air conditioning, or industrial processes);
- **Bidirectional resources** (electric vehicles) that can consume energy but, in some cases, also return it to the grid.

DER management is based on advanced energy management systems capable of automatically coordinating production, consumption, and storage according to the needs of the electrical system.

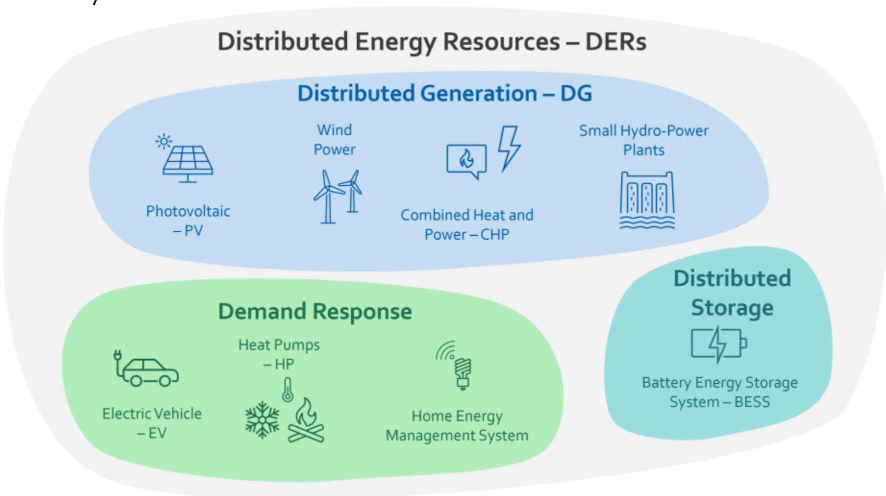

Figure 1 – Description of Distributed Energy Resources (DER).

DER as a possible solution

In this framework, DERs play a central role as **operational tools for distribution network management**, as the flexibility they provide mitigates the critical issues caused by increased electricity demand and the spread of distributed generation (mainly non-programmable renewables), thus reducing the need for structural interventions and improving the overall management of the electricity system.

What are Local Flexibility Markets?

In this scenario, **Local Flexibility Markets (LFM)** play a central role. They were created to activate and coordinate distributed flexibility, defined as the ability of local resources (DER) to **temporarily adapt energy consumption or production**. Through these markets, DSOs can purchase flexibility services from multiple types of resources, often grouped and managed by aggregators (known as Flexibility Service Providers – FSPs). This approach can help reduce congestion, control voltage, and, in many cases, avoid or postpone costly infrastructure upgrades. LFMs complement the ancillary service procurement mechanisms available to Transmission System Operators (TSOs), introducing a "bottom-up" approach that leverages local flexibility and makes customers more involved in the operation of the electricity system. In some pilot projects, TSOs can also purchase flexibility directly from LFMs to solve transmission network issues.

Aggregators play a crucial role in grouping together heterogeneous resources, facilitating market access even for small users. However, operational management presents significant challenges: DERs exhibit variable and not always predictable behavior, and their contribution can undergo rapid changes based on external conditions (sunshine, temperature, plant utilization, etc.). The extent of flexibility available from distributed resources depends closely on the intrinsic characteristics of the resource itself and how it can be controlled, as illustrated in Figure 2.

In addition to the characteristics of individual distributed resources, flexibility mechanisms must take into account different factors that influence the operation of the grid. First, there are **physical limits**, which define how much power and which flows the grid can handle. In addition, production and consumption are becoming increasingly variable and **less predictable** due to the spread of renewables, batteries, and new electrical loads. The picture is further complicated by the presence of **many players**—DSOs, TSOs, FSPs, and active customers—who need to coordinate in order to use flexibility effectively and safely.

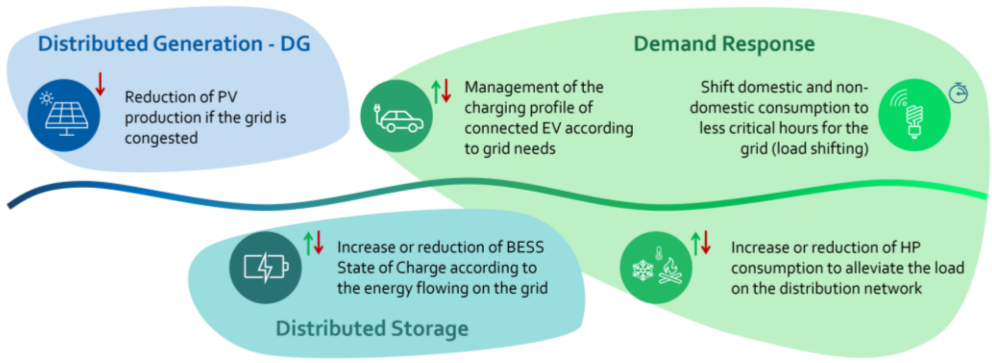

Figure 2 – Examples of Distributed Resources Providing Flexibility.

The regulatory framework

European legislation has played a key role in the development of LFMs. Over the last ten years, European legislators have introduced crucial concepts and instruments, including:

- The recognition of **active customers**, intended as the possibility for citizens and companies to participate in markets with their own resources (mainly indirectly, through resource aggregators);
- The use, where possible, of **market mechanisms** based on transparent, non-discriminatory and competitive procedures;
- The possibility for **DSOs to procure the necessary flexibility** locally and to identify flexibility requirements in their development plans;
- The need for **clear coordination between DSOs and TSO**, avoiding the activation of flexibility services that could create problems at other levels of the system.

Italy has gradually implemented these guidelines (see Figure 3), initiating several pilot projects to test LFM, with the aim of analyzing digital platforms, operating rules, participation methods, and relationships between the various actors. This step is of great importance, as it allows innovative solutions to be tested in the field and provides insights into how to effectively integrate local flexibility into the current framework.

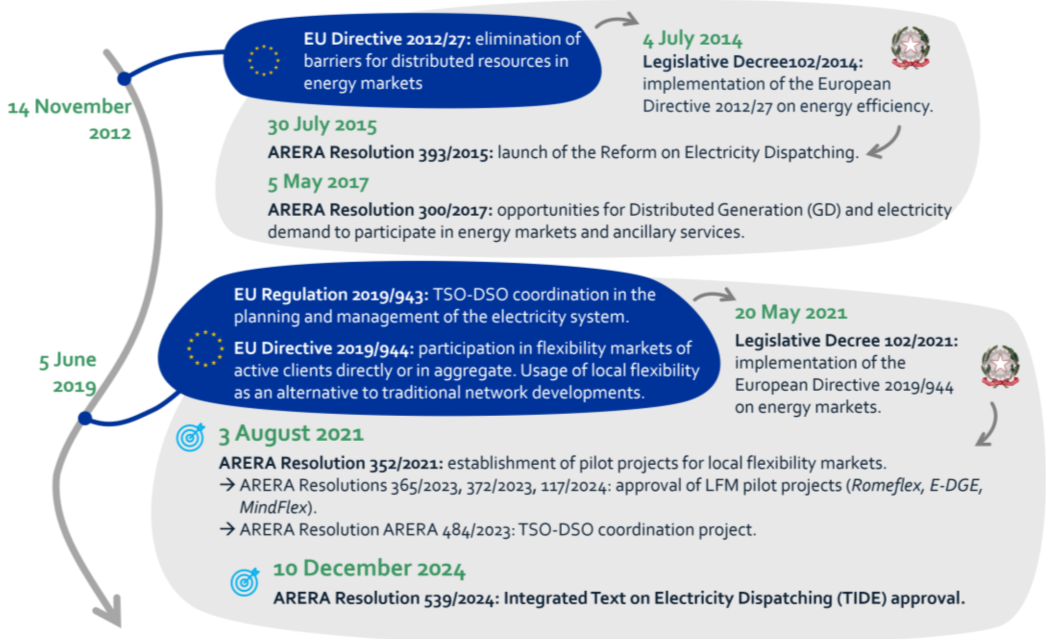

Figure 3 – Regulatory framework on the integration of DERs into the power system.

EU Directive 2012/27

EU Directive 2019/944

ARERA Resolution 352/2021

APE about TIDE

Did you know that…
In the *Integrated Text on Electricity Dispatching (TIDE)* there is already a chapter dedicated to Local Flexibility Markets, but it currently lacks operational provisions. This chapter is still awaiting completion, based on the indications that will emerge from the pilot projects.

EU: European Union.
ARERA: Regulatory Authority for Energy, Networks and Environment.

The LFM platforms and the key stakeholders

To better understand how LFMs work, it is useful to imagine an ecosystem in which different actors collaborate with each other through a common platform. Each collaborator plays a specific and complementary role, necessary for flexibility to be purchased, offered, and used effectively.

The core of the system is represented by the **LFM platform**, which is the digital space where flexibility supply and demand meet. This section is where DSOs submit their requests and operators submit their offers, and where the selection process that determines which services will be activated takes place. LFM platforms integrate a series of advanced coordination, control, and verification tools that allow very different distributed resources to participate in an orderly and standardized manner. In summary, these platforms transform the flexibility needs of the electricity grid into clear and structured processes for the procurement of local flexibility services. A description of the main LFM processes is provided below:

0) **Pre-qualification:** in a preliminary phase, each FSP is assessed to verify that it meets the necessary technical requirements and is reliable in providing the service;
1) **Orders submission:** once qualified, FSPs submit their flexibility orders to the market platform;
2) **Orders validation:** the submitted orders are analyzed to ensure that they are technically feasible and compatible with the state of the network;
3) **Activation (market clearing):** when the network needs flexibility, the operator selects and activates the most appropriate offers. This phase coincides with the closing of the market and the determination of the accepted offers; it can also take place well in advance of the activation phase (point 4), up to several months earlier;
4) **Dispatching:** lastly, detailed operating instructions are provided for implementing the agreed flexibility services.

Piclo Platform

NODES Platform

At international level, the most widely used LFM platforms are Piclo and NODES, the latter being particularly popular in Europe. Most of these platforms are developed by third parties, although in some cases customized solutions have been implemented or developed by the national market operator (Nominated Electricity Market Operator - NEMO). The LFM platform is managed by the **Local Flexibility Market Operator (LFMO)**, which is responsible for collecting bids and offers, applying market rules, and determining accepted volumes and related prices. In some models, the role of LFMO can be performed directly by the DSO, while more often it is a neutral third-party. Alongside the LFMO, there are aggregators, known as **FSPs**, which collect and coordinate the flexibility of many different resources, from small domestic systems to industrial users. **DSO** plays a central role in this process: it identifies local issues, such as congestion, abnormal voltages, and imbalances, and requests flexibility services through the market.

The **TSO**, acting as transmission system operator, is responsible for ensuring coordination between the different layers of the network. Flexibility activated locally must be consistent with the needs of the system as a whole. For this reason, the TSO collaborates with the DSO and, in some schemes, may use part of the available flexibility. Finally, the **Balance Responsible Party (BRP)** is the entity responsible for maintaining the balance between production and consumption in its portfolio and is accountable for any deviations. The BRP can also take advantage of local flexibility, using it to reduce imbalances and improve forecasts. In some cases, the BRP may coincide with the aggregator (FSP). Together, these actors constitute an integrated system (Figure 4) in which flexibility can be activated in a structured, transparent, and coordinated manner, contributing to the efficient management of local flexibility markets.

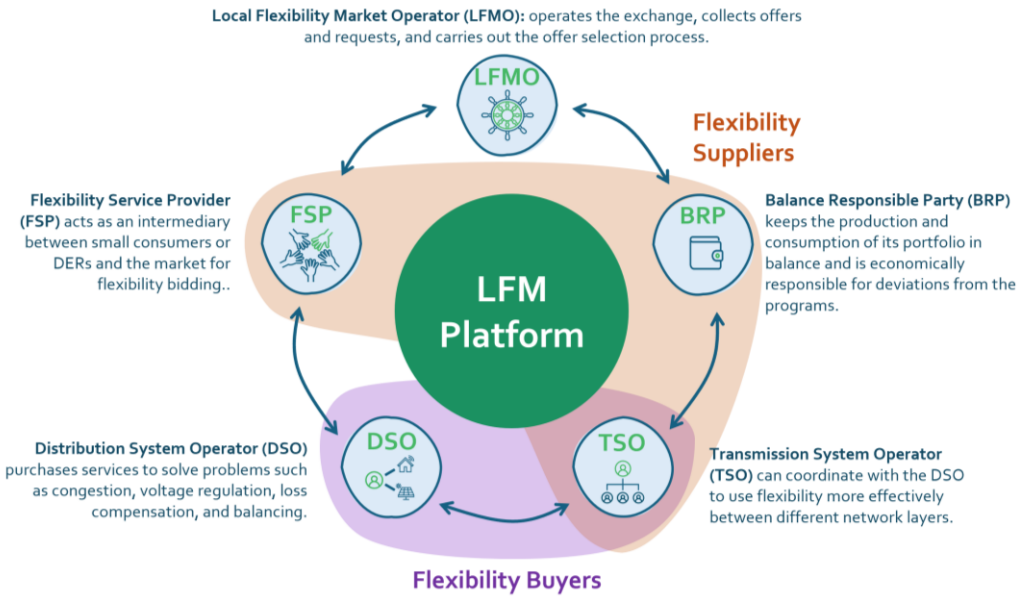

Figure 4 – Key Players in an LFM Market.

The local flexibility services

The flexibility provided by distributed resources can assume different forms, depending on the needs of the power grid. Each flexibility measure is designed to address specific operational issues, including congestion in the most stressed parts of the grid, voltage variations, and maintaining the balance between supply and demand.
Figure 5 clearly illustrates the **three main categories of local flexibility services** that may be requested by network operators within the LFM. These interventions, which include the temporary modulation of active or reactive power, are designed to address different but complementary critical issues.

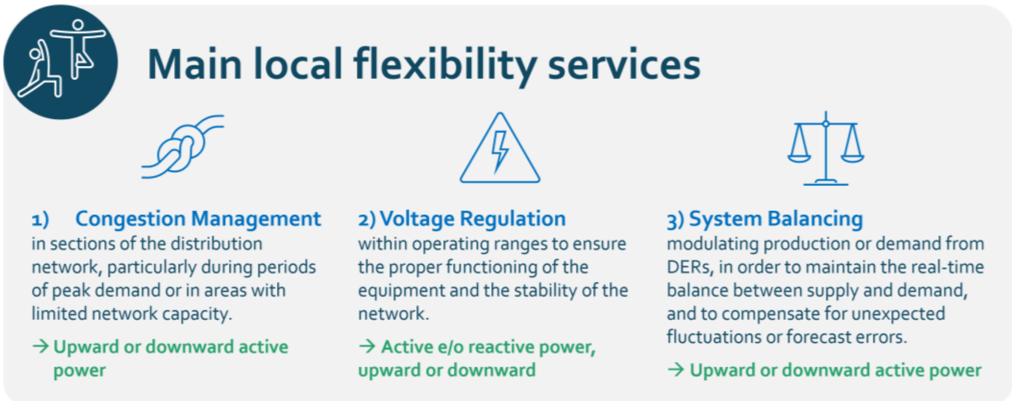

Figure 5 – Main local flexibility services procured on LFMs.

The Market Design

When we talk about **market design**, we are referring to the way in which a market is structured and organized, i.e., the set of rules and decisions that guide its functioning. These designs establish who can participate in trading, how transactions take place, when they take place, and according to which economic criteria payments are recognized. In the case of LFMs, these decisions are particularly important because the market must adapt to specific local contexts and involve a wide range of actors, including small producers, active consumers, and aggregators. Table 1 provides an overview of market configurations for LFM, comparing key classification characteristics with the most common design trends. Specifically, the table organizes the topic along four key dimensions:

- **Participants**: types of users involved and methods of participation (direct or aggregated).
- **Time horizon**: distinction between forward and spot markets based on the time distance from energy delivery.
- **Type of remuneration**: remuneration based on resource availability (in [€/MW]) or actual utilization (in [€/MWh]), or both of them.
- **Pricing mechanism**: rules for pricing and payment of accepted orders.

The right-hand column in Table 1 highlights how these market design choices translate into European and North American experiences, showing significant differences in terms of contractual models, the role of aggregators, and remuneration schemes.

	Classification	Notes
Participants	• **Residential users.** • **Non-residential users**: commercial or industrial users. • **Front-To-the-Meter (FTM)**: Resources connected upstream of the customer meter, directly to the distribution network. They can participate in direct or aggregate mode (FSPs).	In Europe, LFMs are mainly based on participation through aggregators (FSPs). In contrast, in North America, direct participation by residential and non-residential users prevails.
Time Horizon	• **Forward markets**: the price and quantity of energy are determined well in advance of physical delivery (season-ahead, month-ahead or even over a year). • **Spot markets**: the negotiation takes place very close to the delivery time (week-ahead, day-ahead, intra-day and real-time). Fast response times to adapt switches to the operational needs of the electricity system.	Prevalence of forward contractualization. However, some European LFM projects are starting to experiment with spot market solutions, although still to a limited extent.
Type of remuneration	• **Availability-based schemes**: the payment is recognized to the resource remaining available for activation, even if not being actually utilized [€/kW]. • **Utilization-based schemes**: compensation is provided only for the flexibility actually paid at the time of activation [€/kWh].	Availability-based schemes and hybrid compensation schemes (where remuneration is based on both availability and utilization) dominate in forward markets. In contrast, utilization-based schemes prevail in spot markets.
Pricing mechanism	• **Pay-as-bid**: each accepted order is paid exactly the price it offered. • **Fixed price**: the price is set by the LFMO or by the authority. • **Pay-for-performance**: the remuneration depends on the service actually provided (fixed and/or variable component). • **Pay-as-clear**: all participants whose bids are accepted receive the same price, equal to that of the marginal resource that establishes equilibrium.	The pay-as-bid model dominates in European countries (including the United Kingdom). In the United States, however, local flexibility is achieved through programs managed directly by utilities using fixed-price or pay-for-performance models.

Table 1 – Classification of LFMs by type of participants, time horizon, clearing and pricing mechanisms.

What is the current status of LFM

Local Flexibility Markets are currently in an active testing phase, with numerous pilot projects initiated in various countries to test their functioning in real conditions. There is not yet a single, established and standardized LFM model: the LFM pilot projects are designed to understand

development in Italy?

which solutions work best and in which contexts, evaluating market rules, digital platforms, and methods for stakeholder involvement. In Italy, LFM experimentation is currently concentrated in **three pilot projects** (Figure 6), developed on limited portions of distribution networks. The *E-DGE*, *RomeFlex*, and *MiNDFlex* projects involve several network operators and aim to verify how local flexibility can be used to manage concrete problems, such as congestion and voltage criticalities. At this stage, the focus is mainly on defining operating rules, the role of aggregators, and the functioning of market platforms, rather than on the full opening of the market on a large scale. Table 2 compares the evolution of prices, contracted volumes (Figure 7), and participation in the *RomeFlex* and *MiNDFlex* pilot projects over the period considered.

View here the tenders for E-DGE Project

E-DGE Project regulation

RomeFlex Project regulation

MiNDFlex Project regulation

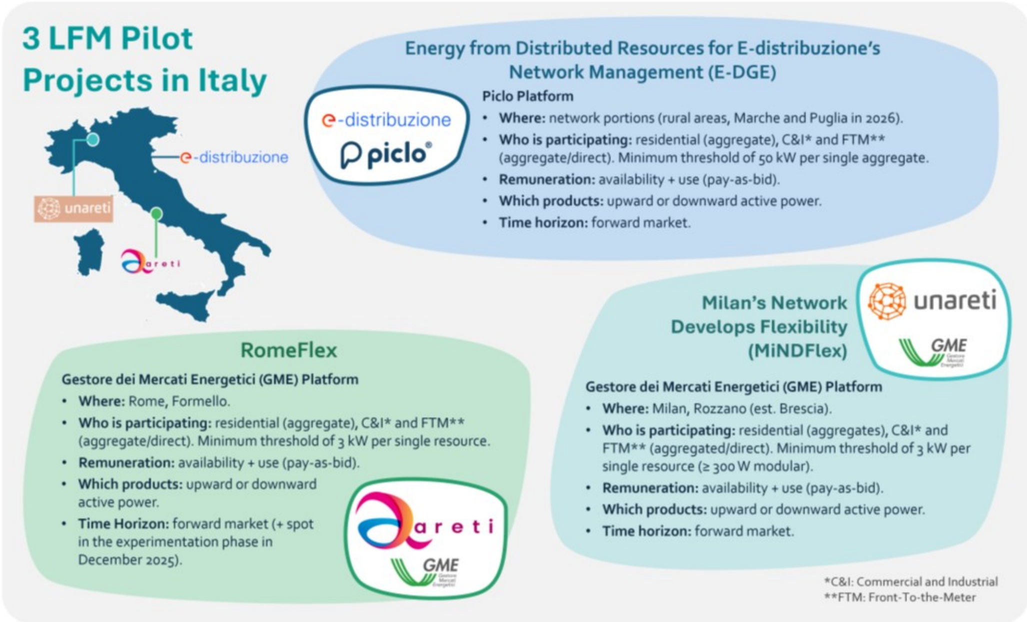

Figure 6 – Pilot projects of Local Flexibility Markets in Italy.

Results of local flexibility tenders	RomeFlex				MINDFlex	
	2023	2024	2025	2026[1]	2024	2025
Number of tenders	1	4	4	2	2	6
Average number of participants	11	7	7	8	2	9
Average price for availability [€/MW/anno]	25.508	56.629	53.044	77.965	30.000	485.929
Average price per utilization (upward power) [€/MWh]	307,20	246,47	278,34	173,37	252,57	68,93
Total quantity accepted [MW]	3,0	19,5	34,4	37,4	9,1	112,8
Total quantity rejected [MW]	0,2	0,02	0	1,6	0	13,6

Table 2 – Results of flexibility tenders (Source: GME platform LFM results).

[1] *Data are updated as of 04/02/2026.*

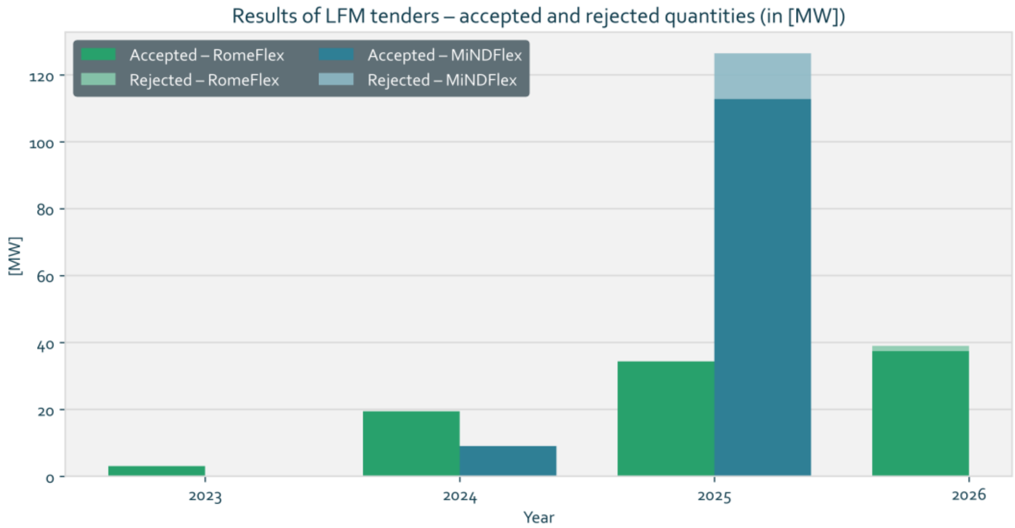

Figure 7 – Accepted and rejected quantities in the LFM RomeFlex and MiNDFlex pilot projects (Source: GME platform LFM results).

In Europe

At the European level, the spread of Local Flexibility Markets is more widespread and complex (Figure 8). In some countries, such as the United Kingdom, several LFM services are already active, while in others, pilot projects are still limited or in the early stages. This distribution reflects differences in regulatory contexts, such as the possibility for DSOs to also manage the sub-transmission network, and in the characteristics of national electricity grids.

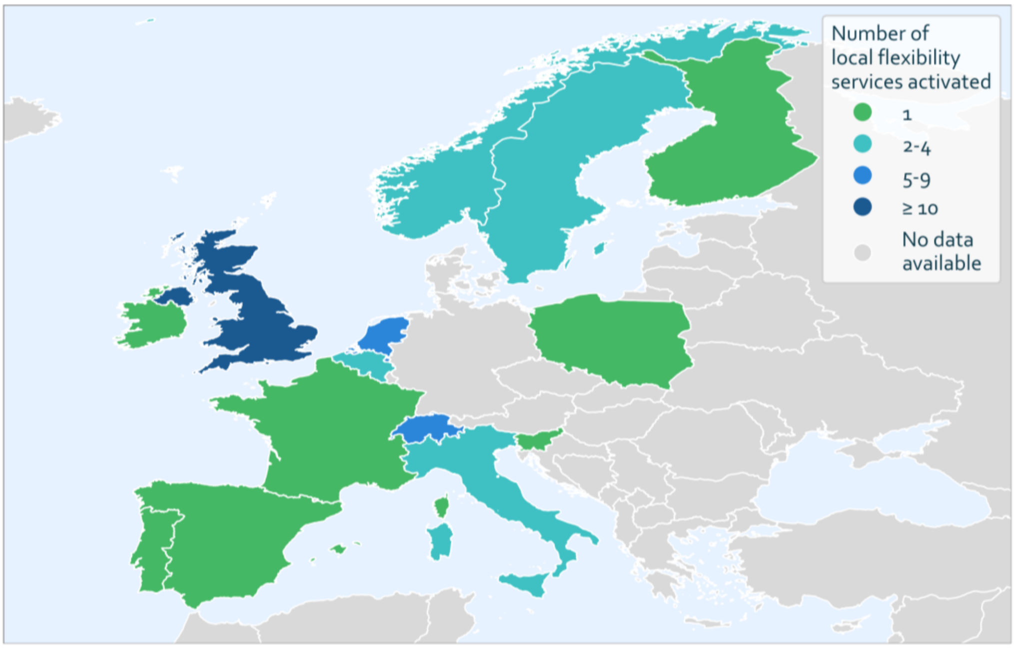

Figure 8 – Distribution of services activated in the Local Flexibility Markets in Europe.

In the world

Looking at the international context (Figure 9), it can be seen that the most advanced experiences are mainly concentrated in North America. In other areas of the world, initiatives are less widespread or still in the exploratory phase. Local Flexibility Markets are currently implemented or being trialed in **19 countries**, where a total of **113 different flexibility products** are traded, reflecting different design approaches and network requirements.

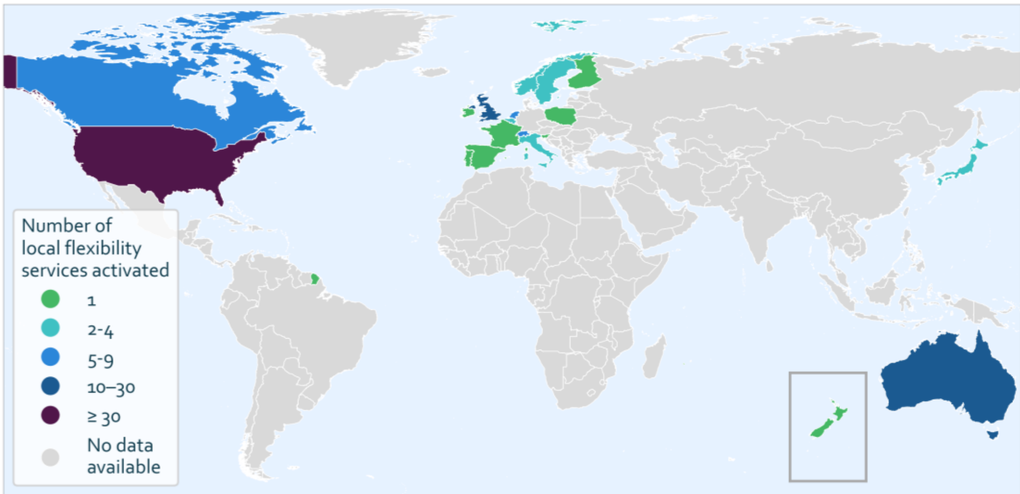

Figure 9 – Distribution of services activated in the Local Flexibility Markets in the world.

Conclusions

Local Flexibility Markets represent a promising tool for accompanying the evolution of electricity systems towards **more decentralized, digital, and participatory models**, in which distributed energy resources play an increasingly active role in grid management. LFMs were created in response to the new operational requirements of distribution networks, which are called upon to manage the growing penetration of renewable generation, storage systems, and new electrical loads.

As summarized in Figure 10, LFMs strike a balance between **significant opportunities and critical issues** that influence their development and large-scale adoption. On the one hand, local flexibility allows for more effective integration of renewable sources, reduces the need for curtailment, and increases the capacity of distribution networks to accommodate new generation and new loads. In addition, the use of LFMs can help defer or avoid infrastructure investments in the grid, while offering new economic opportunities for users and aggregators and leveraging resources that previously did not have direct access to energy markets.

On the other hand, the implementation of LFMs introduces **greater market complexity**, linked to the definition of operating rules, transaction costs, and coordination methods between the various actors involved. Added to these challenges are issues related to the **reliability of local flexibility** and the risk of possible competitive distortions in restricted territorial contexts, which necessitate careful design of market rules and the regulatory framework. However, it should be noted that, unlike the global ancillary services market, the number of entities that can participate in the LFM is inherently limited, as it is linked to congestion occurring on components of the distribution network (HV/MV transformers in primary substations, MV feeders, etc.).

In summary, Local Flexibility Markets are not intended to be a single or definitive solution, but rather a **complementary tool** within a broader set of solutions for managing the electricity system. In this context, **experimentations and pilot projects** play a central role: enable the testing of different market configurations in the field, the assessment of the effectiveness of the adopted mechanisms, and the identification of **simple, reliable models that can be adapted to different local contexts**. The consolidation of LFMs will therefore depend on the

ability to transform the evidence emerging from pilots into scalable solutions that are consistent with the overall evolution of the electricity system.
Finally, a further challenge is how to transfer the contribution from local flexibility services into planning procedures: in the context of medium-term scenarios of load and generation evolution, DSOs must estimate possible critical issues and identify the best combination of traditional investments and flexibility.

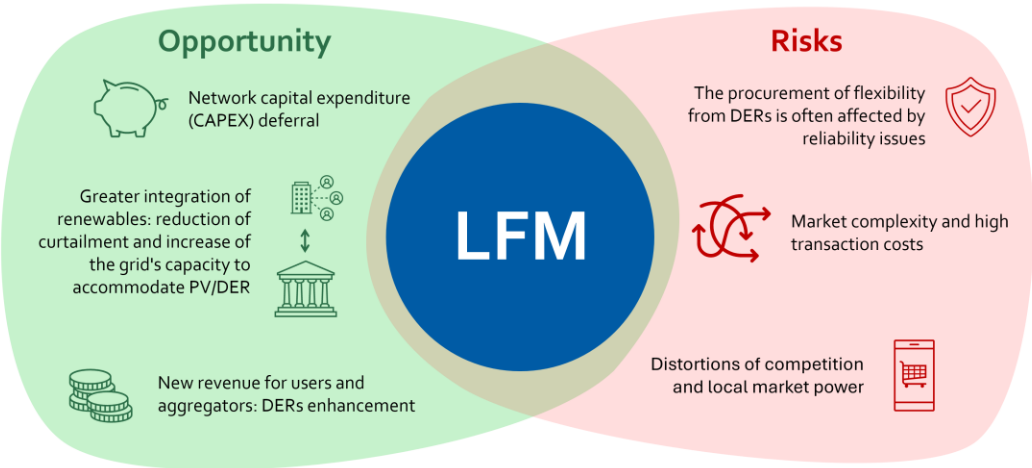

Figure 10 – Opportunities and risks related to Local Flexibility Markets (LFMs).

The author of the report is:

Gianluca Sabbatini

He graduated in Energy Engineering at Politecnico di Milano and he is currently pursuing a PhD in Engineering and Applied Sciences at University of Bergamo. This program is being conducted in collaboration with RSE, and the research topic is local electricity and flexibility markets.

appuntidienergia@rse-web.it

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