

Local Flexibility Markets in Spain: Current Developments and Future Prospects

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Abstract. The increasing penetration of renewable generation in transmission and distribution networks, along with the electrification of end-use sectors, such as transportation and heating, is reshaping the power system. This transition, aligned with the European Union's climate neutrality goals for 2050, requires new flexibility mechanisms to ensure grid stability.

Local Flexibility Markets (LFMs) have emerged as a solution, enabling demand-side participation and optimizing the use of flexible assets in distribution networks. Several European countries have successfully implemented LFMs, while Spain is in an advanced stage of development. This paper analyzes the current state of LFMs in Spain, identifying key regulatory challenges, ongoing pilot projects, and future prospects.

Key words. Local Flexibility Markets, distributed energy resources, renewable integration, demand-side participation, power system stability.

1. Introduction. New Paradigm for the Electrical System

The increasing integration of renewable generation into transmission and distribution systems, along with the electrification of end-uses of energy such as electric mobility and heating systems, represents a key advance toward the decarbonization of the economy. This process aligns with the European Union's agenda for transitioning to a climate-neutral economy, aiming to achieve net-zero greenhouse gas emissions by 2050 [1]. Among the main legislative initiatives driving this process are the European Climate Law [2] and the Fit for 55 package [3].

However, the transition to clean energy presents significant challenges for the operation of electrical grids. Unlike conventional power plants, renewable generation is often less manageable, introducing higher levels of intermittency and variability in energy production. Additionally, the projected increase in electricity demand due to new end-uses exerts additional pressure on distribution networks. These factors create new operational challenges for the grid:

- At the system level, greater flexibility is required to counteract the intermittency of renewable generation and ensure the balance between energy supply and demand.
- At the local level, there is a greater need for flexibility to avoid network congestion or voltage limit violations.

This new scenario requires new flexibility mechanisms to address the needs of the electrical system.

2. Flexibility Services

Flexibility services are specific actions requested by transmission system operators (TSOs) and distribution system operators (DSOs) to maintain the balance of the electrical system and the security and quality of the supply. These services include frequency regulation, power reserve, and voltage control, which are activated to keep parameters such as frequency and voltage within safe limits, or services to resolve network congestion, ensuring that the design limits of network elements are not exceeded.

Providers of flexibility services are generally large generators, storage plants, or flexibility aggregators capable of adjusting their production or consumption. However, the rise of renewable and storage technologies among end consumers also creates flexible active customers in the distribution network, with storage capacity, consumption management, or the ability to inject energy into the grid.

DSOs sometimes require specific services such as:

- Congestion management, which occurs when power flows exceed the design limits of network assets.
- Voltage control, which involves actions on generation resources and reactive power absorption to maintain voltages within specified margins.
- Controlled island operation, which allows creating control systems to ensure supply during unavailability events.

- Service restoration, which aims to return the system to normal operation after a system collapse.

Other important services include balancing services, which regulate frequency and power, and inertia provision (both physical and virtual) to maintain stable frequency [4][5].

List of standardized products by service providers

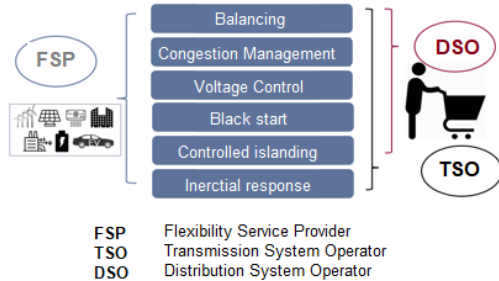


Fig.1. Flexibility services requested by system operators

Both DSOs and network users have various resources to provide flexibility and achieve the decarbonization goals of electrical sector. These resources will connect to distribution networks and help maintain service quality efficiently.

Flexibility services are presented as a priority alternative to network expansion, as established by Article 32 of the European Energy Directive (EU) 2019/944, which encourages evaluating flexibility solutions before investing in infrastructure.

3. Flexibility Mechanisms

Flexibility mechanisms are tools, strategies, or processes used to organize and activate flexibility in the electrical system, allowing supply and demand to be adjusted efficiently. These mechanisms can be implemented through market systems or flexible connection agreements.

Their objective is to facilitate the active management of flexibility, activating available resources (both from DSOs and network users) when necessary to ensure the stability of the electrical system. One of the main mechanisms is LFM [1][6][7].

This paper reviews the local flexibility markets being designed in Spain and identifies their most relevant aspects, as well as the regulations they must comply with and the main national and international projects currently underway in Spain.

4. Flexibility Markets

The electricity markets are differentiated into:

- Global markets: these are European and Iberian electricity markets currently existing on Iberian Peninsula, allowing energy trading with agents located at different points of the Iberian and European grids in a transparent manner, without

considering the location of the producer or consumer, as long as they are directly or indirectly connected to the grid.

- Flexibility markets: These are markets where, due to the specific conditions of the distribution grid to which the installations are connected, exchanges are restricted or must be carried out by installations located in specific locations, and where trading may be promoted or restricted by the distribution system operator. Within these markets, energy products or flexibility services can be traded, offering the capacity of distributed resources to modify their production/consumption based on the requirements of the distribution network operators.

These flexibility markets allow end users to sell the flexibility of energy resources connected at the distribution network level (Fig. 2).

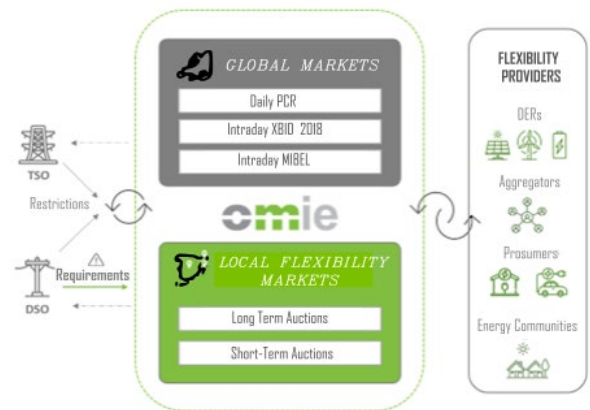


Fig.2. Flexibility Markets [9].

Thus, agents interested in such flexibility can purchase it in LFMs as a complement to traditional mechanisms, such as acquiring flexibility from large power plants or reinforcing networks. Countries like the UK, France, the Netherlands, and Norway already have fully operational LFMs, while others like Italy and Spain have very advanced LFM configurations. Their development process has been directly linked to the creation of a solid regulatory framework for the optimal use of local flexibility.

Local flexibility markets can operate in long-term or short-term modes.

- Long-term LFMs are organized based on DSO requirements announced in advance. In these auctions, flexible resources (DERs) can offer their availability (up or down) to cover the called requirement when necessary during the service window (delivery period).
- Short-term LFMs (for same-day or next-day delivery) operate in two ways:
 - Free (continuous), where agents can participate freely in the areas where their facilities are located.
 - At the request of the DSO (auctions), called under the requirement of a DSO due to

imminent congestion forecast in one of its areas.

These LFM, structure their remuneration mechanisms according to the time frame, clearly distinguishing between availability (long-term) and activation (short-term). In this way, the availability term corresponds to the remuneration that rewards energy resources for being available to be activated, so it is a fixed payment for capacity reservation, even if the DSO does not activate the service. On the other hand, the activation term is an additional payment when the DSO requests the use of the reserved flexibility

5. Regulatory Context for Demand Flexibility in Spain

European regulators recognize the importance of demand flexibility and the role of the aggregator in creating a more resilient, reliable, and sustainable electrical system. The regulatory framework currently guiding the development of regulations in this area at the European level is the Clean Energy Package (CEP) and, in particular, Directive (EU) 2019/944 on common rules for the internal market for electricity and Regulation (EU) 2019/943 on the internal market for electricity [8].

However, the implementation of CEP directives in each Member State has not been as rapid as expected, and most European countries are facing similar issues. In fact, the European Commission recently opened a case against Spain for having only partially transposed the new community rules for the internal electricity market, whose deadline ended on December 31, 2020. At the national level, the regulatory framework for demand flexibility is underdeveloped and dispersed in various existing regulations, which have gradually been modified to transpose European Directives.

- Royal Decree-Law 23/2020, of June 23, which approves measures in the energy sector and other areas for economic recovery, incorporated the figures of storage, aggregation, and independent aggregators, renewable energy communities, hybridization, and regulatory test beds.
- Law 7/2021, of May 20. This law includes in its Final Provision Eleven an explicit mandate to the Government and the National Commission on Markets and Competition to present a reform of the regulatory framework in the energy sector that would promote: (a) the participation of consumers in energy markets, including demand response through independent aggregation; (b) investments in variable and flexible renewable energy generation, as well as distributed generation; (c) energy storage; (d) the optimization of electricity grids, the use of flexibility for grid management, and local energy markets, among others.
- The Climate Change Law contains the regulatory elements of the first National Integrated Energy and

Climate Plan (PNIEC) 2021-2030 and includes as a specific line of action Measure 1.2. "Demand management, storage, and flexibility."

- An accelerator of the same PNIEC is the Recovery, Transformation, and Resilience Plan launched through the EU's NextGeneration funds and within the context of the new European Green Deal. Therefore, in its "Component 8" related to "electrical infrastructures, promotion of smart grids, and deployment of flexibility and storage," it foresees reforms and investments to promote flexibility development.
- Royal Decree-Law 17/2022, urgent measures in the energy sector. This regulation establishes a set of measures of special relevance in the energy sector, particularly for promoting demand flexibility, as it introduces a new active demand response mechanism managed by REE. This mechanism, based on annual auctions, is reserved for demand scheduling units greater than 1MW and is intended to be activated in cases where there is a depletion of the upward balancing energy provided by standard balancing services.

Furthermore, Circular 1/2024, approved by the CNMC, establishes methodologies and conditions for access and connection to electricity transmission and distribution networks. It aims to enhance network efficiency, facilitate demand electrification through flexible access contracts, and ensure transparency in managing access and connection permits. It introduces flexible access capacity and alternative firm capacity to accommodate new entities like batteries and electrolyzers in congested areas

Although the Spanish regulatory context is advancing rapidly, and the foundations for the development of demand flexibility regulation have already been established in our legislation, it is still necessary to work on implementing the regulatory framework that will allow its full development.

6. Current State of LFM Development in Spain

It is necessary to designate an operator for the local flexibility markets to meet the needs/requirements of the DSO. In Spain, this operator is OMIE [9], which already manages the day ahead and intraday electricity and therefore is very well-positioned to manage the LFM as well.

OMIE [1][9], together with the Spanish energy agency IDAE (Instituto para la Diversificación y Ahorro de la Energía), developed a preliminary design of the Spanish LFM system. The project in which the LFM design was developed is called IREMEL [1][10].

The main objective of IREMEL was not only the creation of LFMs but also to facilitate the participation of renewable generation and consumption resources connected to distribution networks in conventional

electricity markets. It should be noted that these developments will be the basis for the development of the LFM market in Spain in the near future.

Currently, the implementation of LFM concepts by OMIE is under development. These developments are being carried out within the framework of various European projects (ReDREAM, DRES2MARKET, STREAM, V2MARKET, REEFLEX) [10].

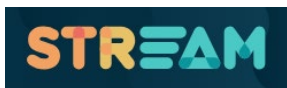
The next phases will include the development of pilot projects within the framework of regulatory "sandboxes." The preliminary list of projects accepted by IDAE in November 2024 includes three sandboxes: FlexAbility, S2F, and Energía del Prat [11].

1) *STREAM. Streaming flexibility to the power system*

The aim of this project is to develop an innovative and robust flexibility ecosystem that enables the exchange of information between DSOs, responsible for medium- and low-voltage networks, the local flexibility market platform managed by OMIE, and new active players with renewable resources. Its goal is to create a flexibility market capable of interacting in real-time with various distributed resources, promoting their use in a more technically and economically efficient manner. Additionally, STREAM fosters the integration of renewable energy, improving its management and contributing to a more sustainable energy system [12].

OMIE will provide a market tool, "sMART local market," focused on the user and on the low-voltage side of the electrical grids, to carry out decision-making processes before, during, and after each flexibility requirement auction period.

This platform serves as a central hub for flexibility market activities, where participants range from flexibility service providers registering their devices, to flexibility capacity aggregators and distribution network managers. In this way, the DSO can send its flexibility requirements through this application, triggering a local flexibility capacity auction.



2) *REEFLEX. Soluciones de flexibilidad interoperables y replicables.*

The REEFLEX project (REplicable, Interoperable, Cross-sector Solutions and Energy Services for Demand Side FLEXibility Markets) [13] aims to develop a set of interoperable solutions and services that increase consumer participation in flexibility markets. These services and solutions are based on the development of an interoperable central platform, which serves as an energy marketplace to connect all types of energy system actors, providing them with access to any flexibility market (local, national, European) and offering a range of interactions and services tailored to their energy needs. To ensure the

interoperability of the central platform, REEFLEX places a strong emphasis on demonstrating and replicating these solutions across seven different countries with varying energy constraints (Spain, Greece, Switzerland, Bulgaria, Denmark, Turkey, Portugal).



3) *ReDREAM*

The European project ReDREAM works in four energy communities across different locations (Spain, Italy, the United Kingdom, and Croatia) with the aim of promoting active consumer participation in the electricity market through the development of technology that enables an open and co-creative ecosystem. This is achieved by implementing digital measuring devices that simplify the task and allow for a thorough understanding of the energy uses that can offer flexibility in homes and businesses, while providing tools to offer them without compromising comfort [14].

OMIE participates in the definition of the new information flows that need to be raised for the connectivity of the Redream ecosystem in the existing global markets, as well as the local flexibility markets under development.

The developed devices are connected to electrical equipment (such as air-to-water heat pumps, photovoltaic inverters, and electric vehicle chargers) to control their usage according to the network's needs. These devices allow for the switching on or off of equipment at optimal times, maximizing the utilization of available renewable energy.

ReDREAM includes a cloud-based platform and artificial intelligence that helps consumers manage their energy consumption from a single point. This encourages more efficient use of resources, reducing costs and environmental impact.

ReDREAM has been tested in over 700 homes and facilities in countries such as Spain, Italy, the United Kingdom, and Croatia. The initiative has demonstrated that consumers can take an active role in the energy transition, improving their energy habits by up to 13%.



4) *DRES2MARKET*

The DRES2Market project is a European initiative funded by the Horizon 2020 program that aims to facilitate the active integration of distributed renewable energy generation (such as solar photovoltaics and wind power) into electricity markets and the provision of ancillary services to the electrical system [15].

This project does not only to study the behaviour of the integration of different volumes of renewables and

distributed generation in current global markets, but also to test the platforms for the local flexibility markets. The main objectives are:

- Evaluation of technologies and regulations: Existing technologies, grid codes, and market rules were analyzed to identify limitations and opportunities.
- Active participation of consumers: The project promoted the role of end consumers as active players in the energy market, facilitating their interaction with renewable technologies.
- Positive impact: The project highlighted the social, economic, and environmental benefits of greater integration of renewable energies.

The DRES2Market consortium included 15 institutions and companies from six European countries (Spain, France, Greece, Norway, Poland, and Austria).



5) V2MARKET

The V2MARKET project is a European initiative aimed at integrating and utilizing electric vehicle (EV) batteries as energy storage systems and tools for grid flexibility [16]. This project focuses on exploring technologies such as Vehicle-to-Grid (V2G) and Vehicle-to-Building (V2B), which enable bidirectional charging of electric vehicles. This means that EVs not only consume energy but can also return it to the grid or buildings when needed, contributing to the stability of the electrical system and the energy transition towards renewable sources. The project studies how EV batteries can contribute the wholesale and local electricity markets in Spain and Europe.

The project has carried out two pilots in Spain:

- Fleet of the Metropolitan Area of Barcelona (AMB): Electric vehicles used with smart software to simulate real charging and discharging.
- Homes with photovoltaic self-consumption: In collaboration with Holaluz, the integration of EVs in homes equipped with solar panels was tested.

Both pilots demonstrated that EV batteries can effectively respond to the energy demands of the grid and buildings



6) FlexAbility

FlexAbility is a sandbox project focused on the flexibility of the distribution grid. Its main goal is to test new solutions for managing flexibility in electricity distribution networks, encouraging the participation of consumers and prosumers, as well as the integration of renewable energies [17].

This initiative focuses on demand flexibility and distributed generation to enhance the balance between supply and demand in distribution networks, aiming to define a business model for independent aggregators in wholesale electricity markets and Local Flexibility Markets (LFMs). It introduces innovative solutions to optimize existing infrastructure, minimizing the need for new investments, while experimenting with dynamic demand management, energy storage usage, and distributed resource optimization to lower grid operational costs. The project is being implemented in various regions of Spain in collaboration with Red Eléctrica de España (REE) and local electricity distributors.

7) S2F (Service-to-Flexibility)

The S2F project aims to facilitate the transition to a flexible energy model by promoting the active management of flexibility in the electrical system through the use of digital technologies, enabling active participation from consumers [17]. The project proposes use cases with LFMs and flexible access contracts.

S2F aims to develop mechanisms and platforms to manage flexibility at the distribution grid level by integrating resources such as batteries, demand-side management systems, and distributed renewable energy. The project leverages digital technologies, including smart meters, real-time communication platforms, and predictive algorithms, to anticipate network needs and activate flexibility resources. Additionally, it seeks to enhance transparency in flexibility markets and create new business opportunities for aggregators and active consumers. This initiative has been implemented in various regions of Spain in collaboration with Red Eléctrica de España (REE) and key technological stakeholders in the energy sector.

8) Energía del Prat

The Energía del Prat project is a local energy sandbox aimed at transforming the municipality of El Prat de Llobregat into an intelligent and sustainable energy ecosystem [17]. The goal is to harness the local grid flexibility to improve energy efficiency and reduce CO₂ emissions.

This project focuses on transforming the city into an energy self-sufficient hub by utilizing storage technologies, intelligent demand management, and local renewable generation. It incorporates innovative solutions for managing distributed energy within a local community context, leveraging smart grids, digital flexibility platforms, and active citizen participation in energy management. The initiative aims to improve energy efficiency, lower energy costs for residents, and support the decarbonization of the area through local renewable sources such as solar power and energy storage. Developed in collaboration with local stakeholders and technology companies in the energy sector, this project highlights El Prat's commitment to sustainable energy transition.

8. Conclusions

This paper provides an in-depth analysis of the current state of Local Flexibility Markets (LFMs) in Spain, focusing on their development, regulatory challenges, and opportunities for integrating distributed energy resources into the electrical grid. The key points are as follows:

- **Development of LFMs:** Spain is in an advanced stage of developing LFMs, which are essential for managing the increasing penetration of renewable energy and the electrification of end-use sectors. These markets enable demand-side participation and optimize the use of flexible assets in distribution networks.
- **Regulatory Challenges:** The regulatory framework for demand flexibility in Spain is still evolving. While significant progress has been made, including the incorporation of storage, aggregation, and independent aggregators into national legislation, further work is needed to fully implement and harmonize these regulations with European directives.
- **Pilot Projects and Initiatives:** Several pilot projects and initiatives are underway to test and refine LFM concepts. These include projects like STREAM, REEFLEX, ReDREAM, DRES2MARKET, V2MARKET, FlexAbility, S2F, and Energía del Prat. These projects aim to develop innovative solutions for managing flexibility, integrating renewable energy, and enhancing consumer participation in flexibility markets.
- **Opportunities for Integration:** LFMs present significant opportunities for integrating distributed energy resources into the grid. By facilitating the active management of flexibility, these markets help ensure grid stability, reduce the need for network expansion, and support the transition to a decarbonized energy system.
- **Alignment with Decarbonization Goals:** The development of LFMs is closely aligned with Spain's and the European Union's decarbonization goals. By promoting the use of renewable energy and enhancing grid flexibility, LFMs contribute to achieving climate neutrality by 2050.

Overall, the paper highlights the importance of LFMs in the context of the energy transition, emphasizing the need for continued regulatory development and the implementation of innovative pilot projects to fully realize the potential of these markets.

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